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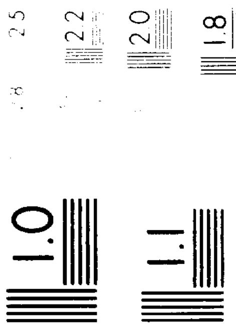

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IMPROVING OF STEELMAKING AND CONTINUOUS CASTING

DP/SYR/79/003

Syria. Technical report: Steelmaking and continuous casting of Gecosteel

Prepared for the Government of Syrian Arab republic by the United Nations Industrial Development Organization, executing agency for the United Nations Development Programme

1981

Based on the work of Mauri O. Peltonen. expert in continuous casting of steel

United Nations Industrial Development Organization
Vienna

This report has not been cleared with the United Nations Industrial Development Organization which does not, therefore, necessarily share the views presented.

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I. INTRODUCTION

The steelmaking and continuous billet casting plant of Gecosteel has produced about 2500 tons in average per month during the last two years against a rated capacity of 10 000/12 000 tons per month. The assignment given to the undersigned is to assess the situation and to suggest means to improve production , improve quality and reduce disturbances. There were no statistics about different disturbances and no investigation has been in the past. First task was to make some investigation concerning situation prevalent and to take action.

The following are taken into consideration for planning my work. Lots of persons from Gecosteel had been sent to Europe for schooling and training before commission of the new plant, but the majority of these people has been shifted for other works. New workers in their place have not been schooled or trained systematically (this concerns engineers, foremen and workers). Under the circumstances the main task of the undersigned was to teach and train the persons on fundamentals of continuous casting and (steelmaking). Undersigned was prepared to give a course to engineers, foremen and key workers about continuous casting. Material for the course prepared was more than enough. I intended to have a course for small groups of 3-5 persons conversant with English and German language. Unfortunately it was not possible to arrange the course as Gecosteel could not organize it during my stay there.

Need for information about steelmaking and continuous casting being very essential the undersigned tried to furnish this information during disucssions with different persons. The best possible practical achievements have been reached as results of direct discussions with foremen and key workers. Some foremen and key workers can speak and/or communicate German language surprisingly well. Such types of discussions have been made also with engineers.

The undersigned has made investigations concerning typical problems and at the same time made several reports and recommendations from time to time. Reports have been made for cases which have some problems. A list of all reports made by me is given in annex 12, some of them are included in this report as annexes.

I have also handed several technical reports and papers concerning steelmaking and continuous casting mostly in English language and some in German. Gecosteel has taken copies out of them. Gecosteel has hardly any such technical information in common use. A list of these technical papers is in annex 19.

This report is made relatively long as this will serve the purpose of schooling also. To try to improve schooling Gecosteel will send some people abroad for training in different steel works.

It is very necessary for persons going abroad for training to read this report as well as the reports annex 12 and 19, especially for the subjects on which they are concerned. Training in other steel plants abroad will not give enough benefit unless the person is familiar with the problems of his own plant. The plant where training will take place cannot give time for basic knowledge. Information about sensing and recommendations have been given in the report about different aspects.

II. TECHNICAL REPORT ON STEELMAKING AND CONTINUOUS CASTING AT GECOSTEEL

1. Description of equipments

The plant units were commissioned towards end 1977. The plant is established to produce billets to supply the rolling mills which has been already in production with imported billets. The rated capacity of steelplant and continuous casting is 120 000 tons/year of good billets of Ø 80 - Ø 120 mm size (at present Ø 80 and Ø 100 is cast). The entire production can be supplied to the rolling mill which is also of the same rated capacity . The plant is designed to use scrap and sponge iron as raw material, but sponge iron is not in use so far except for some trials. The main eequipments are 2 BBC electric arc furnaces each max 30 tons with max transformer capacity 15 MVA, and 2 Concast billet casters. In annexes 1-7 general technical data of electric arc furnace are given. Similar data for concasting are in annexes 8-9. As a general layout of the complete plant is not available in a small size, it could not be enclosed. At present only St 37 steel is being produced, which is required for making different sizes of reeinforcements of bars and rods in the rolling mill.

2. Steelmaking and quality required for continuous casting

Steelmaking process is not dealt with here very much, but the main emphasis is made about steel required for continuous casting to get a good product quality and a good operation. Attention should be paid to the following:

- proper temperature of the steel
- fluidity of the steel to be good and consistent from one charge to another
- Al-content should be low enough to prevent blocking of tundish nozzles
- deoxidization of steel should be such, that there is not boiling and splashing in mould and tundish

- slag quantity in the steel should be low, because slag deteriorates castability and causes breakouts and surface defects in the billets
- impurities in the steel must have certain limits for the continuous casting process.

For example, Concast AG has given the following limits for one billet caster:

S	.035 % max	
P	.030 "	billet size ⊄ 100- ⊄ 140
P+S	.050 "	bending radius 5 m
Cu	.30 "	
As	.04 "	
Sn	.03	
Sb	.04 "	

The steel is made in a 40 tons arc furnace. Al adding in the furnace ladle and tundish is not to exceed 200 g/ton steel (Al in alloyings is included).

If the limits of the above elements go up, the steel becomes hot short and incidence of cracking increases.

$\frac{Mn}{S}$ > 10 for making merchant steels and $\frac{Mn}{S}$ > 20 for making special steel. (Valid in C area 0 -08 - .25 %).

The above aspects are dealt with some more details below indicating the present situation in Gecosteel and recommendations for improvements.

2.1 Proper temperature of steel

The undersigned has made two reports about steel temperatures submitted to Gecosteel.

a. Importance of steel temperature for successful continuous casting (on 28-2-81) and

b. Investigation of steel temperature in ladle and tundish at Gecosteel (on 7-6-81).

In other reports given to Gecosteel importance of temperature has been stressed.

Whenever casting temperature is mentioned it normally means tundish temperature in connection with continuous casting. This temperature is slightly higher than the temperature of the casting stream into the mould. The casting temperature should be high enough to allow troublefree starting and finishing of casting. For a proper quality and operation need, the casting is to be done at as a low temperature as far possible. As a golden rule the difference of temperatures of deoxidized steel in ladle and solidifying steel in mould should be minimum.

The following are the important disadvantages of high steel temperatures.

- Internal and surface cracks will increase.
- Central porosity and segregation of alloy elements in steel will increase.
- Consumption of refractory material increases at each step.
- Breakout rate increases and repair of breakouts becomes more difficult.

The steel temperature of different qualities of steel can be specified by calculating of liquidus temperature. Liquidus temperature can be calculated on the basis of alloy elements in steel. Calculation instructions with tables and examples , how to calculate have been supplied by the undersigned to Gecosteel.

For casting St 37 steel the tundish temperature can be relatively high (15°C to 55°C over liquidus temperature). According to measurements taken under my direction, the ladle temperature can be kept in the area 1620°C to 1660°C. Higher temperatures than the above are not required.

The following deals with how far Gecosteel has been successful in implementing temperature control and recommendations for improvements. The following graph indicates steel temperature deviations of ladle in different casts made during Nov./Dec. 1980 in a period of two weeks.

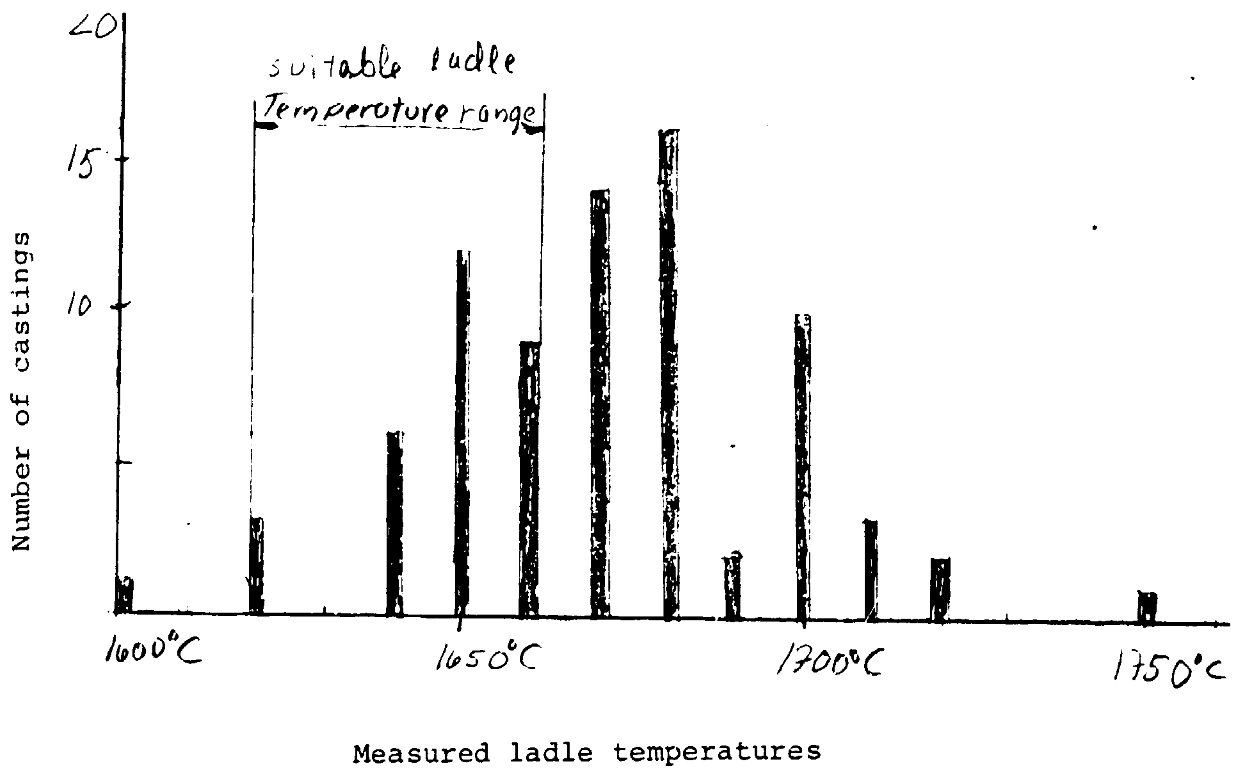


Fig 1.

It can be seen that 40 % of these temperatures were in the desired limits (1620°C - 1660°C). In other words 60 % of ladle temperatures were above desired limits. A campaign has been made to improve this very bad situation. The following results have been achieved during the campaign:

	% of all charges in suitable temp.area
January	62
February	72
March	65
April	78
May	58

The following graphs are showing more accurately the temperature deviation in different months.

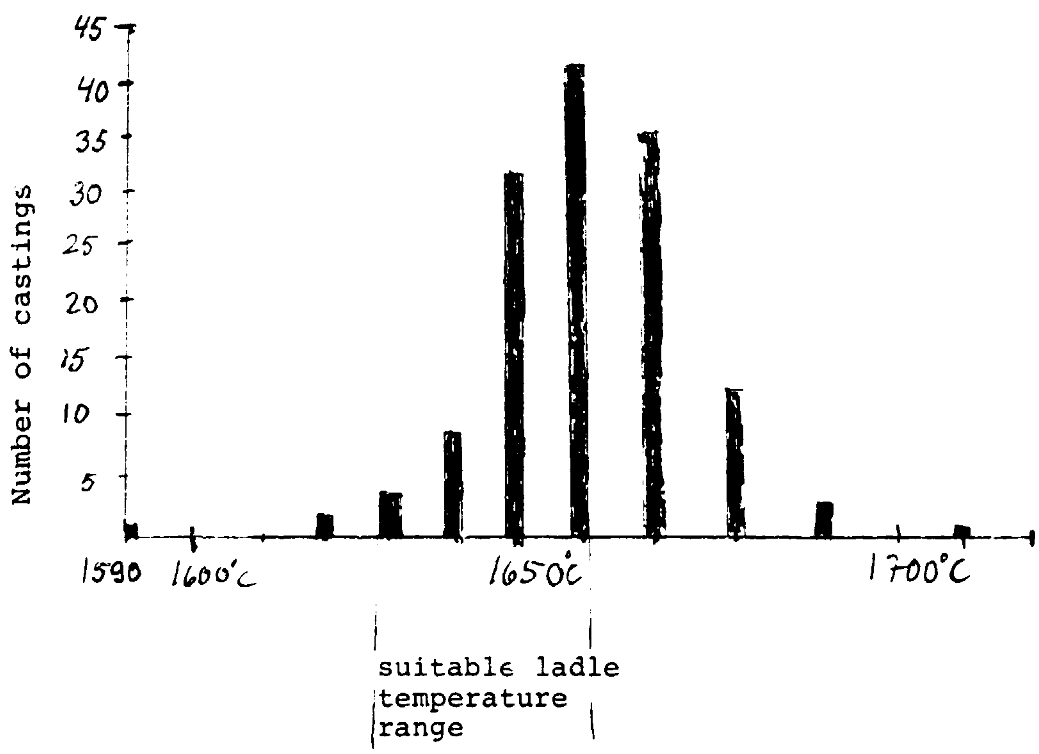


Fig 2. Ladle temperatures in January 1981.

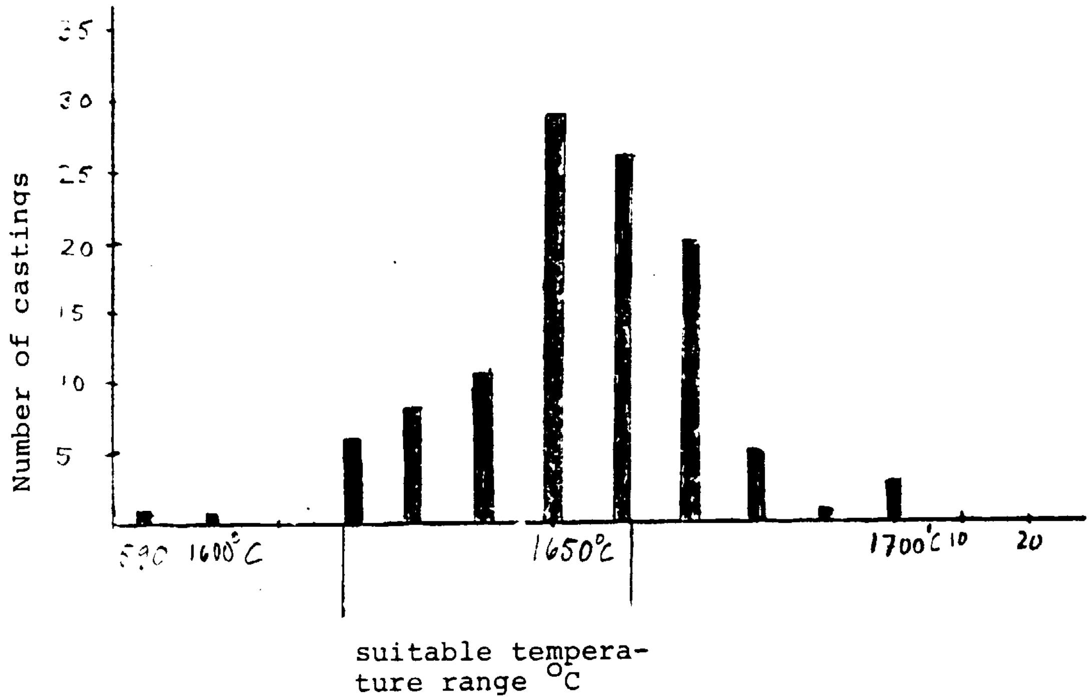


Fig. 3 Ladle temperatures in February 1981

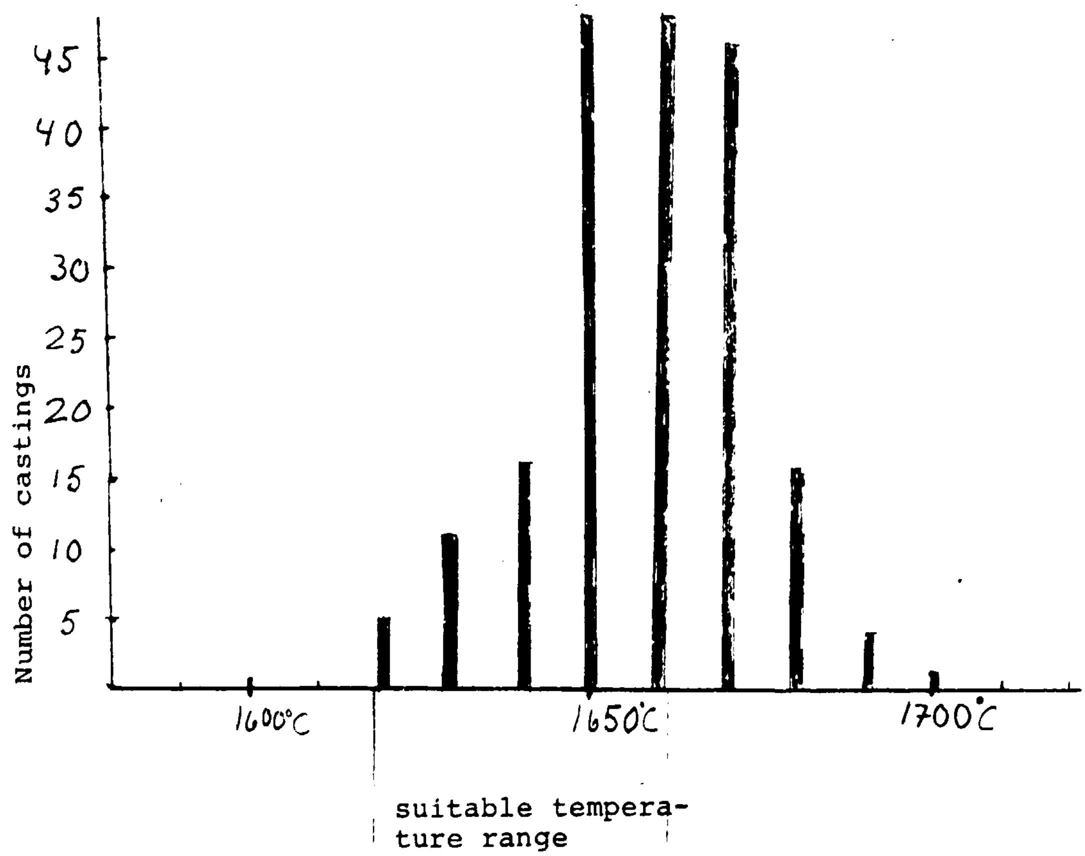


Fig. 4 Ladle temperatures in March 1981

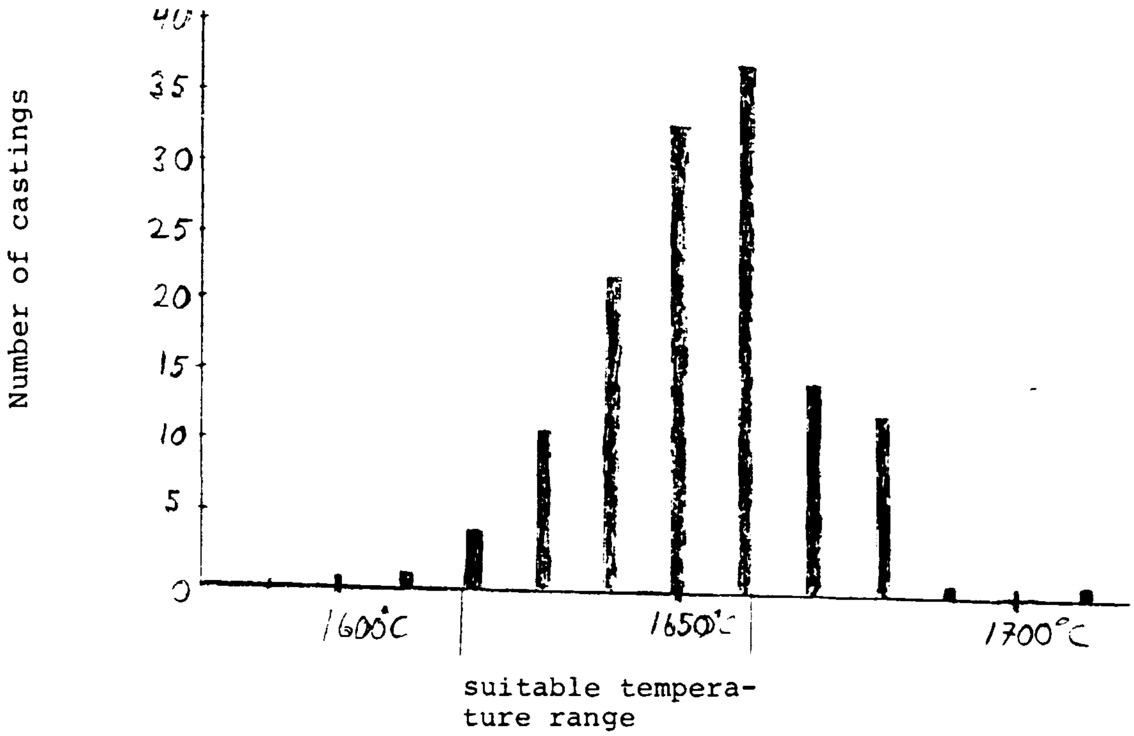


Fig. 5 Ladle temperatures in April 1981

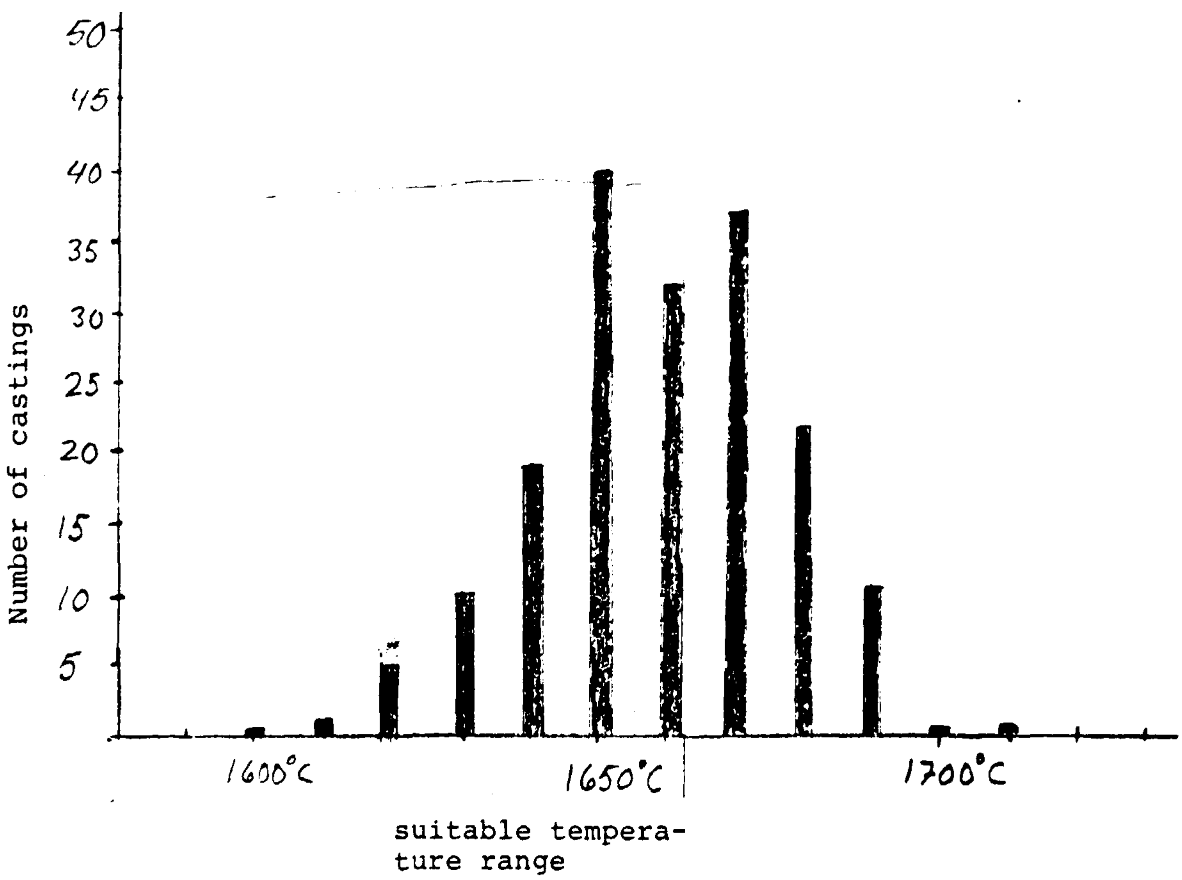


Fig. 6 Ladle temperatures in May 1981

The target should be 90 % of temperatures in ladles in the desired area. High casting temperatures had really deteriorated operation results and billet quality.

Recommendations

a. During a steelmaking process it is necessary to control the furnace temperature more efficiently. More measurements of the steel temperature is to be taken avoiding measuring slag temperature.

b. A steelmaking process needs more efficient control.

c. The tapping time should be consistent so that the temperature during tapping should not vary too much. Tapping spout and hole should be maintained properly.

d. Preheating of ladle should be effective and circulation time of ladle should be minimum possible.

e. The importance of temperature should be pressed to all concerned and control exercised at all levels to achieve the desired results.

f. All temperature measurement instruments should be properly maintained, checked and calibrated with standard instruments at stated intervals.

g. It is almost necessary to have gas stirring stations for ladle near a continuous casting plant.

h. It is important to continue the investigation of temperatures as being done by the undersigned during continuous casting operation.

2.2 Fluidity of steel

Fluidity of steel deteriorates when the quantity of slag increases, Al-content increases and temperature goes down. The fluidity of the steel at Gecosteel is widely fluctuating. With CaSi-adding into tundish fluidity can slightly be improved. This method is commonly used at Gecosteel.

2.3 Al-contents in steel should be low enough to prevent blocking of tundish nozzles

If the Al-content in steel is too hıgh (for billet casting > .004 to -006 %) the tundish nozzle sets blocked gradually resulting stopage of casting. In the following Fig. 7 the blockage of tundish nozzle is illustrated.

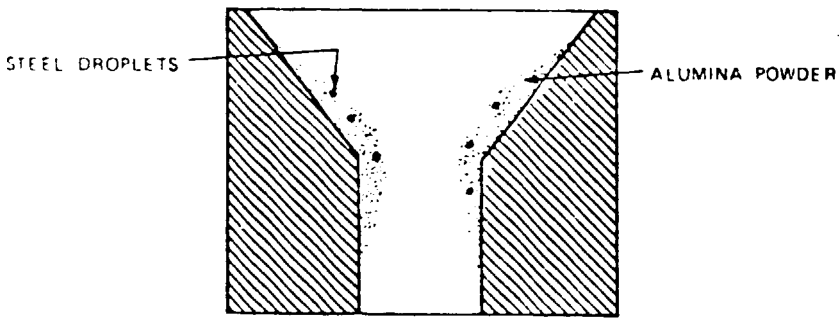
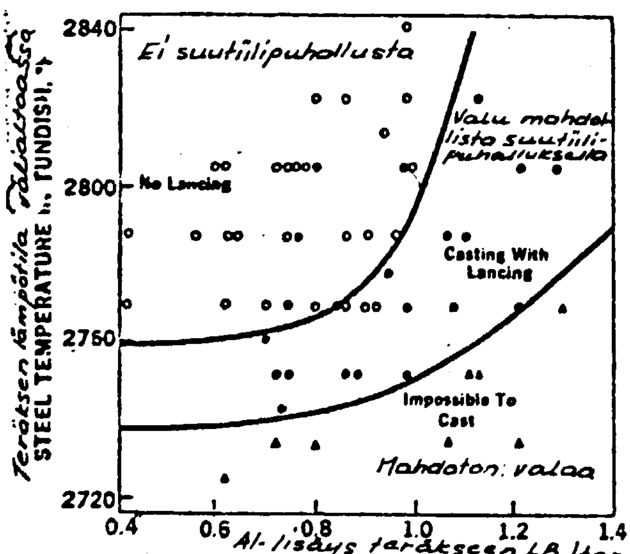


Fig. 1—Typical tundish nozzle cross section showing the regions where alumina powder generally deposits.

Fig. 7

Blocking also to some extent depends on the temperature of the steel as shown in Fig. 8

Effect of aluminium and steel temperature on casting operation



Al-adding in steel LB/ton

Fig. 8

If the temperature of the steel is above normal, it may be possible to cast with a little higher Al-content. This can be one of the reasons why steel temperature in Gecosteel is kept higher than the desired limits.

Al comes to steel with alloys and deoxidizing elements. It is also added to some extent in the furnace, ladle and sometimes in tundish to improve deoxidation.

To make correct Al-adding in steel, it is necessary to know the oxygen acitivity (free oxygen content).

Oxygen acitivity depends very much on carbon content of steel (Fig. 10). The deviation of carbon-oxygen relation is much bigger with low carbon contents. In Fig. 11 example of relation between carbon content and Al-addition is shown from another steel plant.

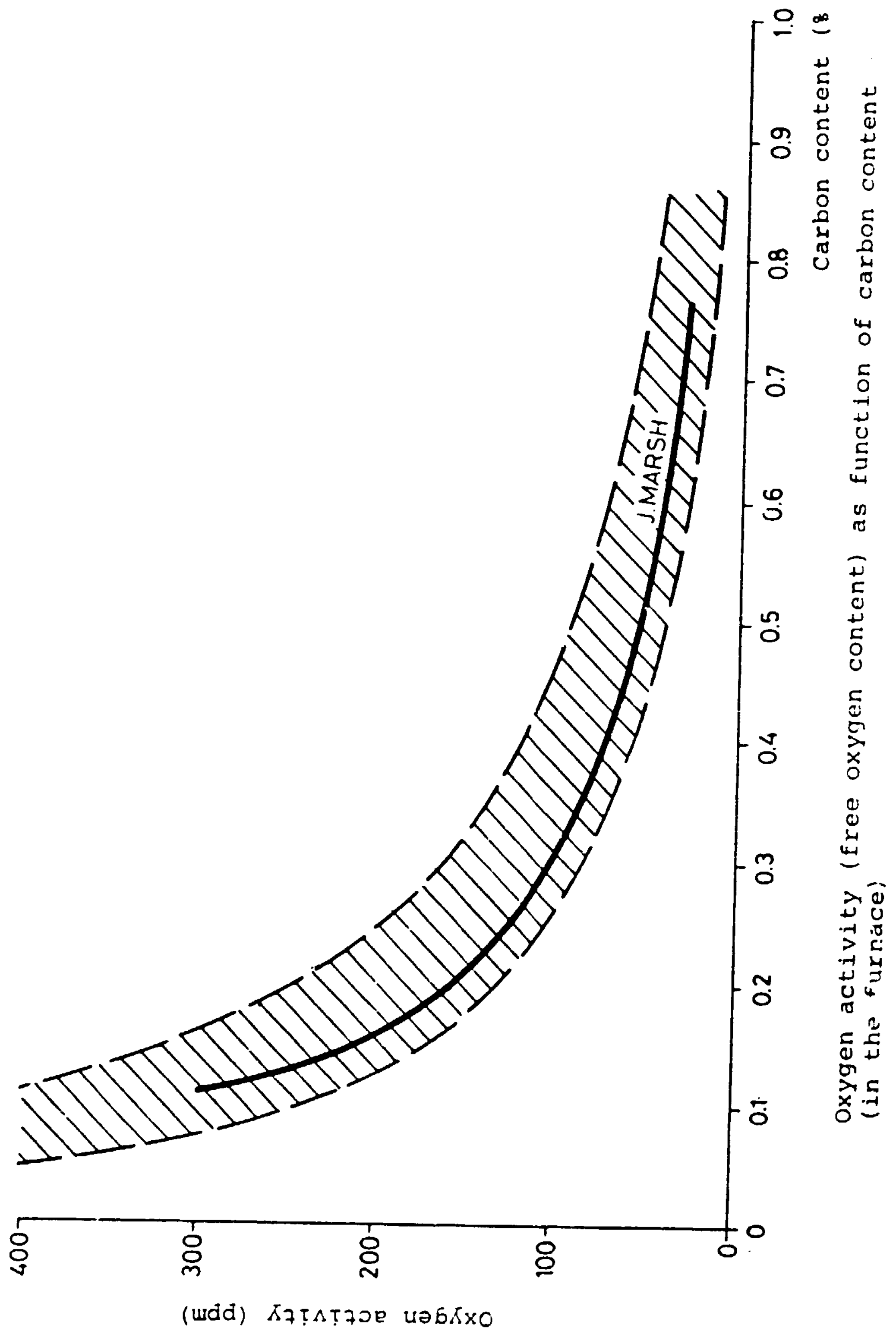
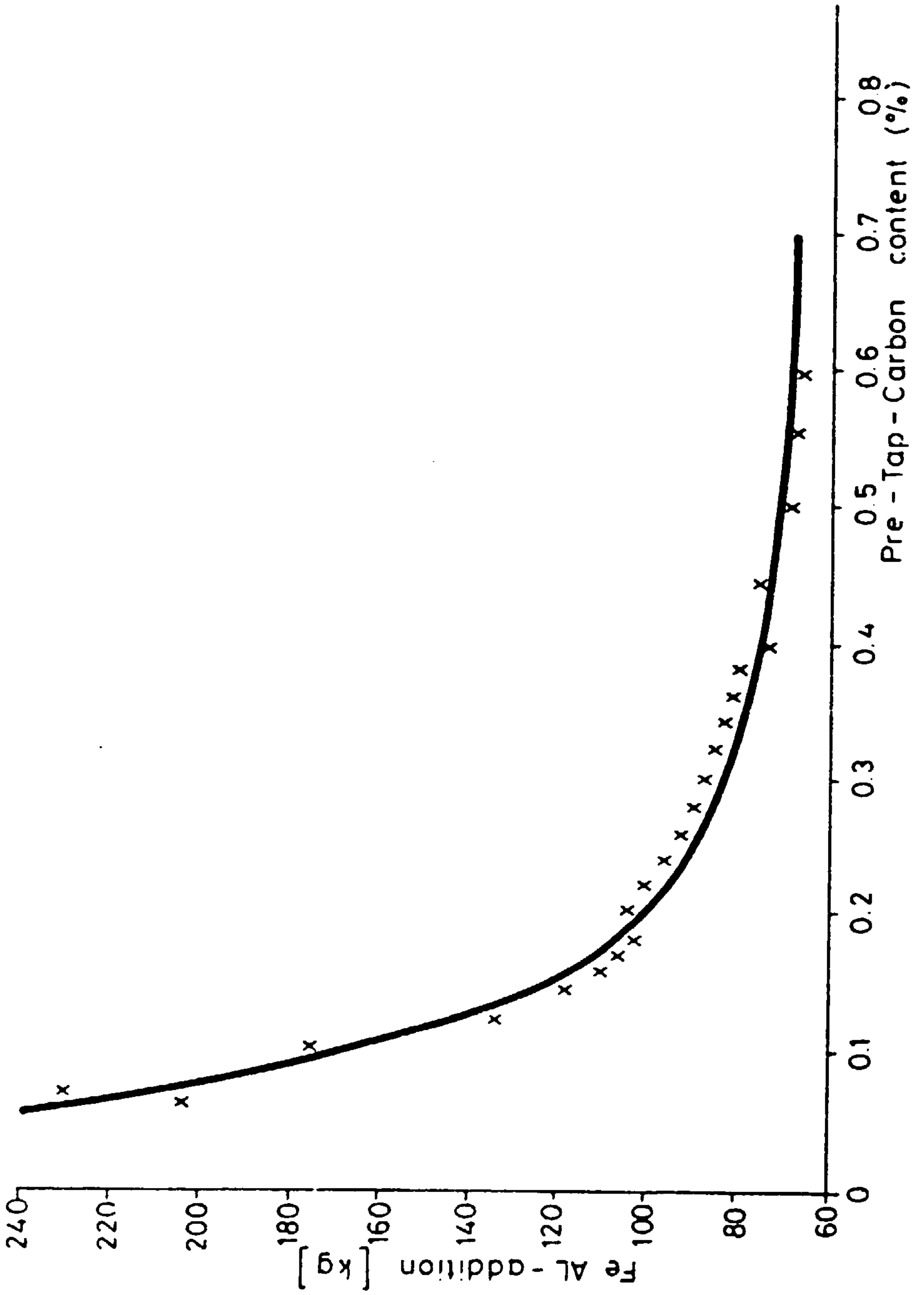


Fig. 10

Adding Al at random will cause strong deviation of deoxidation. In Fig. 12 we can see the dependence of total oxygen and active oxygen on the carbon content.

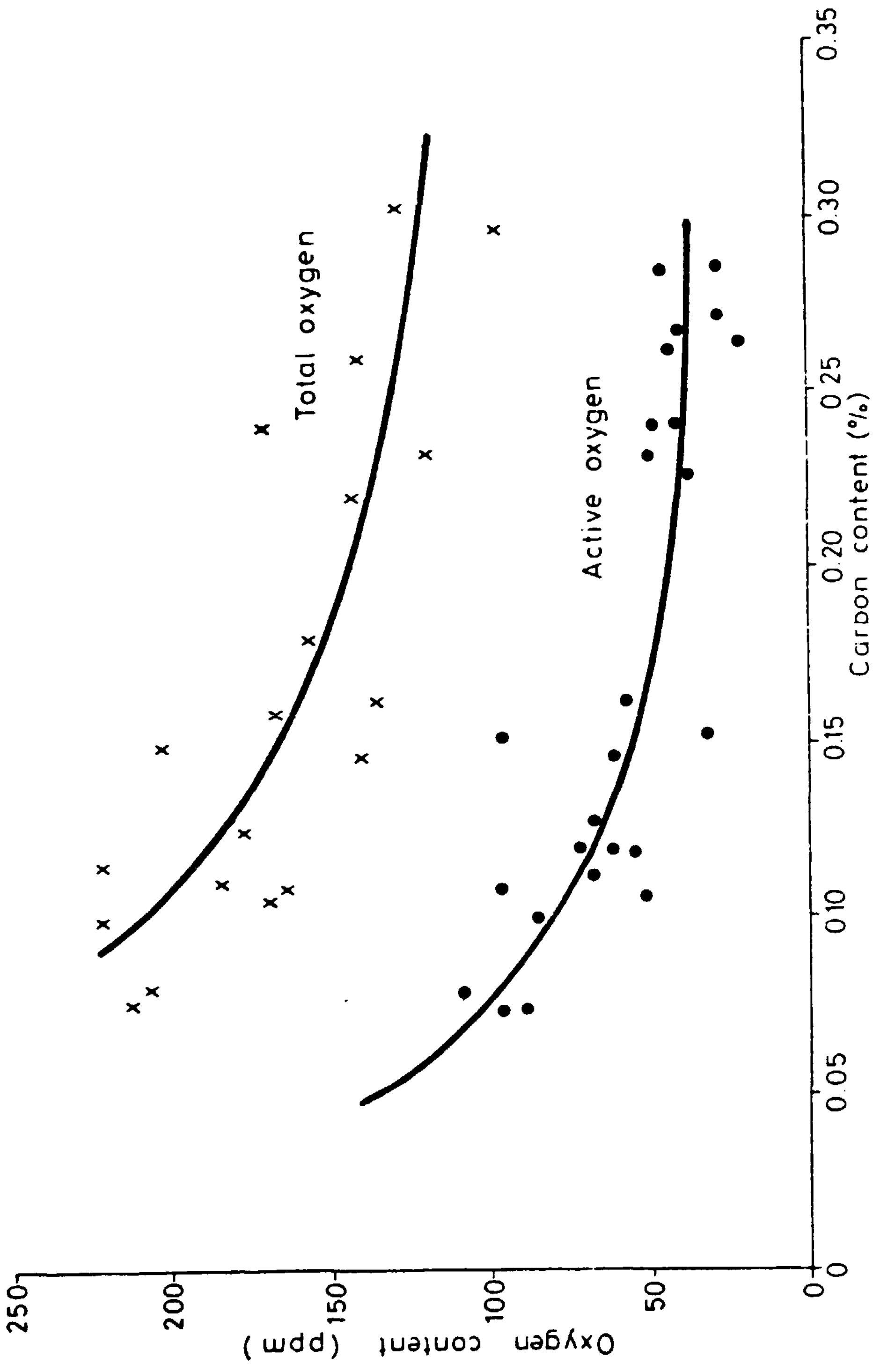


FeAl-addition as function of Pre-Tap-Carbon content (for primary bath deoxidation)

Fig. 11

From the Fig. 12 it can be seen that the main part of oxygen is bound in oxides. Gasstirring in ladle can reduce the oxides but not active oxygen. Due to this soluble Al-content is not getting reduced.

In case the level of oxides in steel should be low, some reoxidation takes place in the stream between ladle and tundish resulting in formation of Al-oxides. Al-oxides can also be formed due to reaction



Total and active oxygen content in the ladle (after nitrogen stirring) as function of carbon content.

Fig. 12

between molten steel and refractory lining. Recently several castings at Gecosteel have tundish nozzle blockage. Sometimes casting was possible due to high temperature, but when the temperature went down during casting, blockage occurred. In one case the tundish nozzle got blocked at the temperature 1545°C of steel in tundish even though calculated liquidus temperature was 1508°C. Blocking of tundish nozzle which results in sending back of steel, happens soon after start of casting and therefore the production losses are high.

Recommendations

a. Operation practice at each stage of steelmaking must be improved.

b. If ferro-Al can be used instead of Al, better and more even deoxidation results can be achieved. Ferro Al alloy can go better into the steel and its reaction time will be longer compared to pure Al. Due to fluctuating steelmaking conditions the use of Ferro-Al is recommended.

c. It is recommended to have a new graph showing the relation of carbon content and Al (FeAl) addition (in furnace and ladle).

d. It will be easier to keep control if Al is added for primary deoxidation in the furnace. In that case it may not be necessary to add Al in the ladle at the time of tapping. In case addition of Al is found necessary in the ladle, the quantity will be low. (80 to 120 g/ton steel).

e. Communication between personel of continuous casting and steelmaking must be improved, so that a prompt and accurate information is passed on in case of blockage etc for correct action for the next cast.

f. Gasstirring in ladle has a marginal effect in preventing blockage in tundish nozzle (influence is negligible).

2.4 Deoxidation of steel should be good

For continuous billet caster casting of unkilled or semikilled is difficult or even impossible. If it is observed that steel is boiling in tundish and mould, steel should be sent out immediately from the continuous casting area. In same cases when boiling is not much, it may be possible to continue the casting by adding Al or CaSi in the tundish. Partly deoxidized steel is coming to the casting shop fairly often. Deoxidation can sometimes be really bad, and silicon contents 0.02 - 0.04 % have been found in analysis in such cases. Fig. 13 - 14 show internal structure of billets in case casting of partial deoxidized steel.

Recommendations

a. Accuracy of steelmaking must be improved.

b. Better results may be achieved if deoxidation is done partially in the furnace. Al-addition should be made as per chart of carbon content % - Al-addition, Ferro-Al in place of Al will make a better deoxidation.

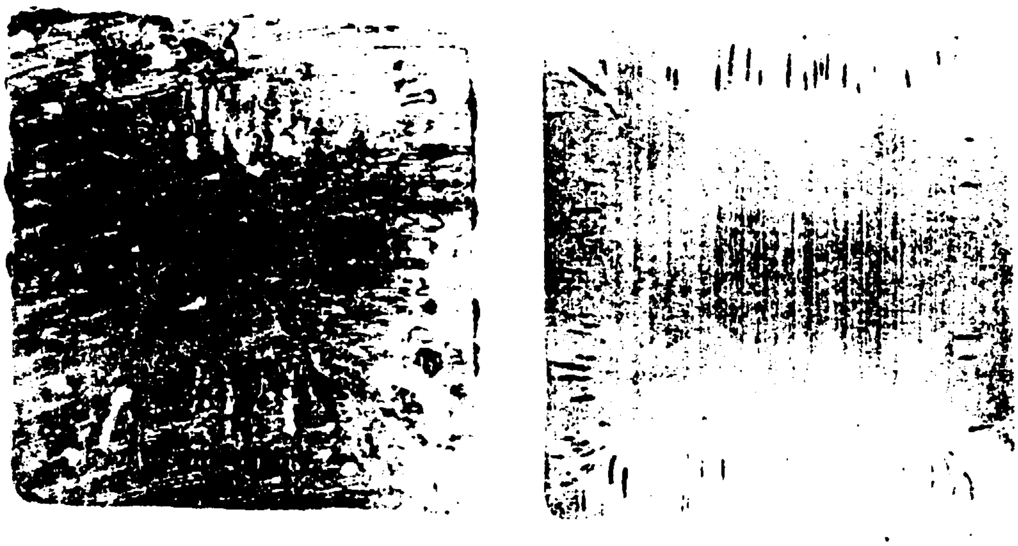


Fig. 13. Blowholes in transverse section of billet.

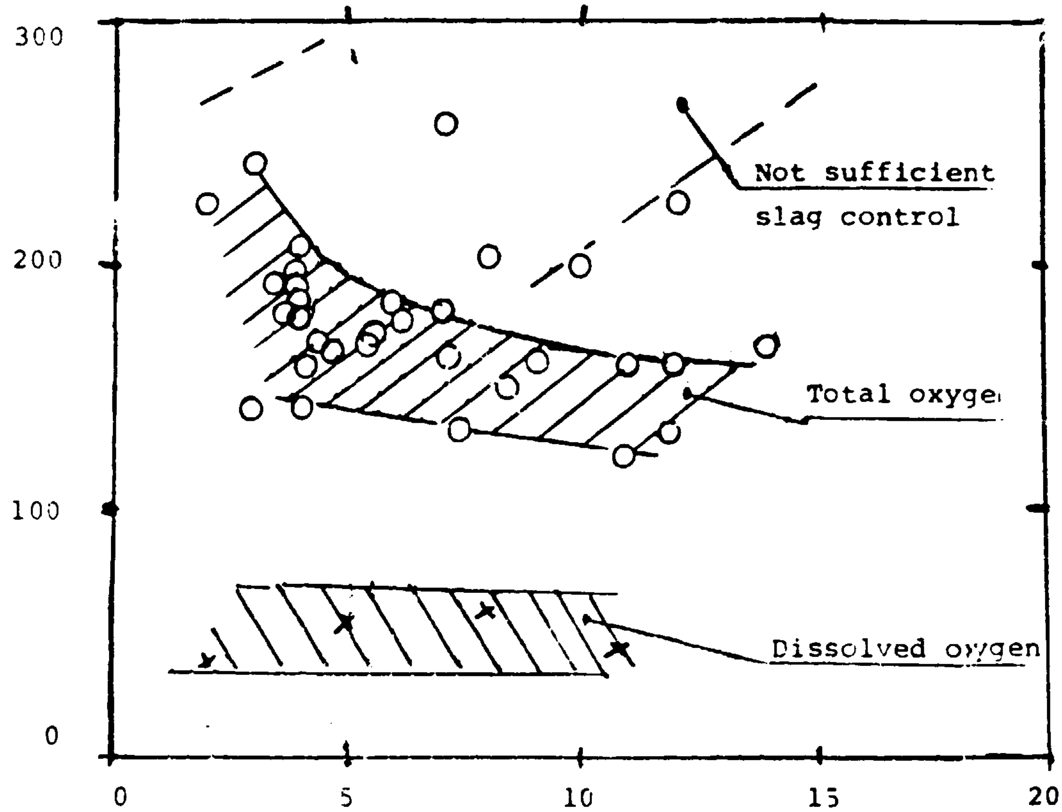
Fig. 14 Blowholes in longitudinal section of billet.

2.5 Slag in steel to be low:

Large quantities of slag in steel cause many problems in casting operation. For example the rate of breakouts increases, stream between tundish and mould becomes flattering. Casting has often stopped due to the above problems. Casting speed varies and sometimes goes down due to slag. Large variation of casting speed causes uneven mould and secondary cooling resulting in cracks in billets.

It is possible to control slag volume to some extent with $\frac{Mn}{Si}$ ratio. This ratio should be 2.5 to 3 which will enable slag to remain in the steel without coming out to the surface and disturb the casting. With $\frac{Mn}{Si}$ ratio 1.5 slag floatation from steel is maximum. More about the slag formation is given in a separate report "Problems with slag by steelmaking and continuous casting",dated 11th april 81 (annex 10).

If it is not possible to keep fluctuation level of oxygen in steel-making in furnace under control, then deoxidation in ladle while tapping often causes increasing of slag. For this it will be better to make the major part of deoxidation in the furnace. In the following graph (F9g. 15) total oxygen content in ladle has gone down due to gasstirring but dissolved oxygen remains more or less constant.



Picture OXYGEN CONTENTS AFTER GASSTIRRING, Si-KILLED STEEL, STANDARD SLAG AND TAPPING PRACTICE. OXYGEN BEHAVIOUR FROM A PRACTICE GIVING BAD SLAG CONTROL IS INCLUDED FOR COMPARISON

Fig. 15

This result means that the amount of oxide slags is reduced by gasstirring. This investigation was made in Norrbottens Järnverk in Sweden.

One example of slag problem is given below.
Charge No. 1-412.
A large quantity of slag was coming out to the steelsurface in tundish and mould. Casting was stopped after 10 minutes due to this. The tundish was changed and casting started but some problems

came up. Chemical analysis of the steel gave the following result:

C	Mn	S	P	Si	$\frac{Mn}{Si}$
.10	.45	.03	.025	.39	1.15

Due to low ratio of Mn/Si the above problem of high slag formation occurred. On some other day, the Si-content was .02 % in one cast. In both cases Si-additions to the furnace and ladle showed about the same according to furnace report.

In case of higher silicon content casting, the furnace was repaired by spraying MgO (magnesite). It was essential that residual steel was there in lining. Because of this, magnesite came out during melting (about 1 ton). Under such circumstances it is not possible to control volume and composition of slag (slag analysis is not being done at present).

Fluctuation of oxygen control of steel must be very high from charge to charge.

Recommendations

a. Steelmaking needs improved control. A report of steelmaking in Gecosteel is given in annex 11.

b. It is important to have gasstirring arrangements as soon as possible.

c. It is necessary to start some kind of quality control of billets, so that data regarding surface defects due to slag are available.

d. Information about billet surface regarding slag must be communicated to steelmaking shop and recorded in the casting report.

e. The possibility of slag analysis is to be looked into and introduced.

2.6 Impurities in steel

During the period the undersigned was in Gecosteel (November - June) the spectrometer was out of order. Making chemical analysis is difficult and takes more time. Analysis of all necessary elements are not possible now. The spectrometer was sent to Germany for repair, but unfortunately it was received back in a damaged condition during transit after repair.

Normally C, Mn and S are analysed for steelmaking, and in some cases Si and P are also analysed. Under the prevailing condition control of P, S, Cu, As, Sn, Sb is difficult. For hardness increasing elements like Cr, Ni and Mo the same problems are there.

The scrap used is not classified and stored in different bins. Scrap coming from outside as well as own arisings in the plant are used as and when available.Analysis of scrap is not normally feasible. Fluctuation of scrap composition must be very high under these conditions. This is also apparent from the quality of the billets, fluctuating tensile strenght (often very high) and problems of rolling of such billets in the rolling mill.

Due to nonavailability of scrap in time, all types of scrap being available at site are used. Hence it is not possible to know the composition of scrap going into the furnace for melting. The quality output from furnace also cannot be forecast or analysed accurately. The deteriorating effect of S, P, Cu and Sn from some other plants is indicated in Fig. 16.

Hot shortness of steel increases due to higher % of these elements as a result incidence of cracks are increasing in billet. For Gecosteel it should be possible to limit to the following maximum values.

$S \leq .040$ $P \leq .040$ $S + P \leq .070$ $Cu \leq .35$ $Sn \leq .040$ $Cu + 10Sn = .70$

These values must be ensured when the spectrometer is available.

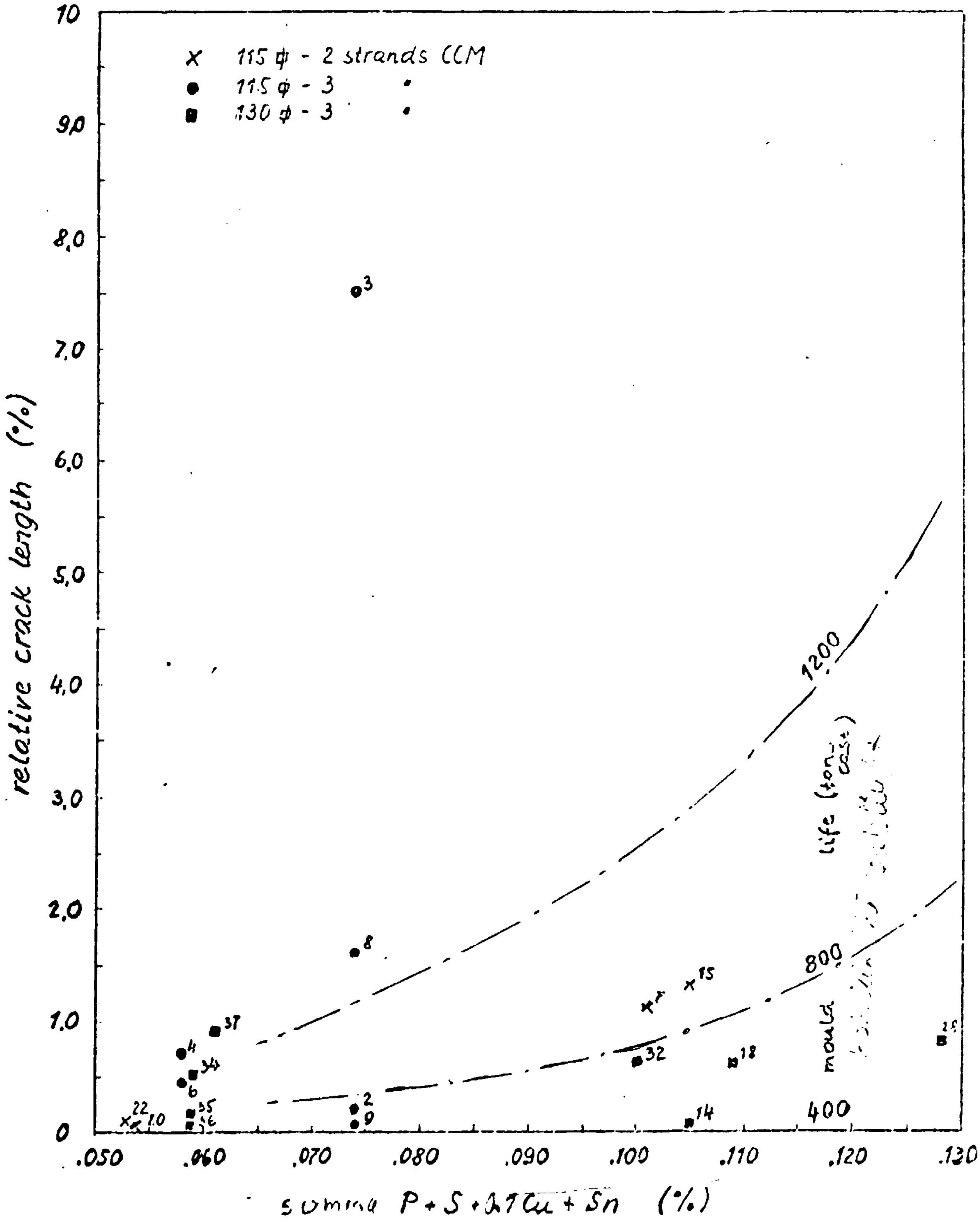
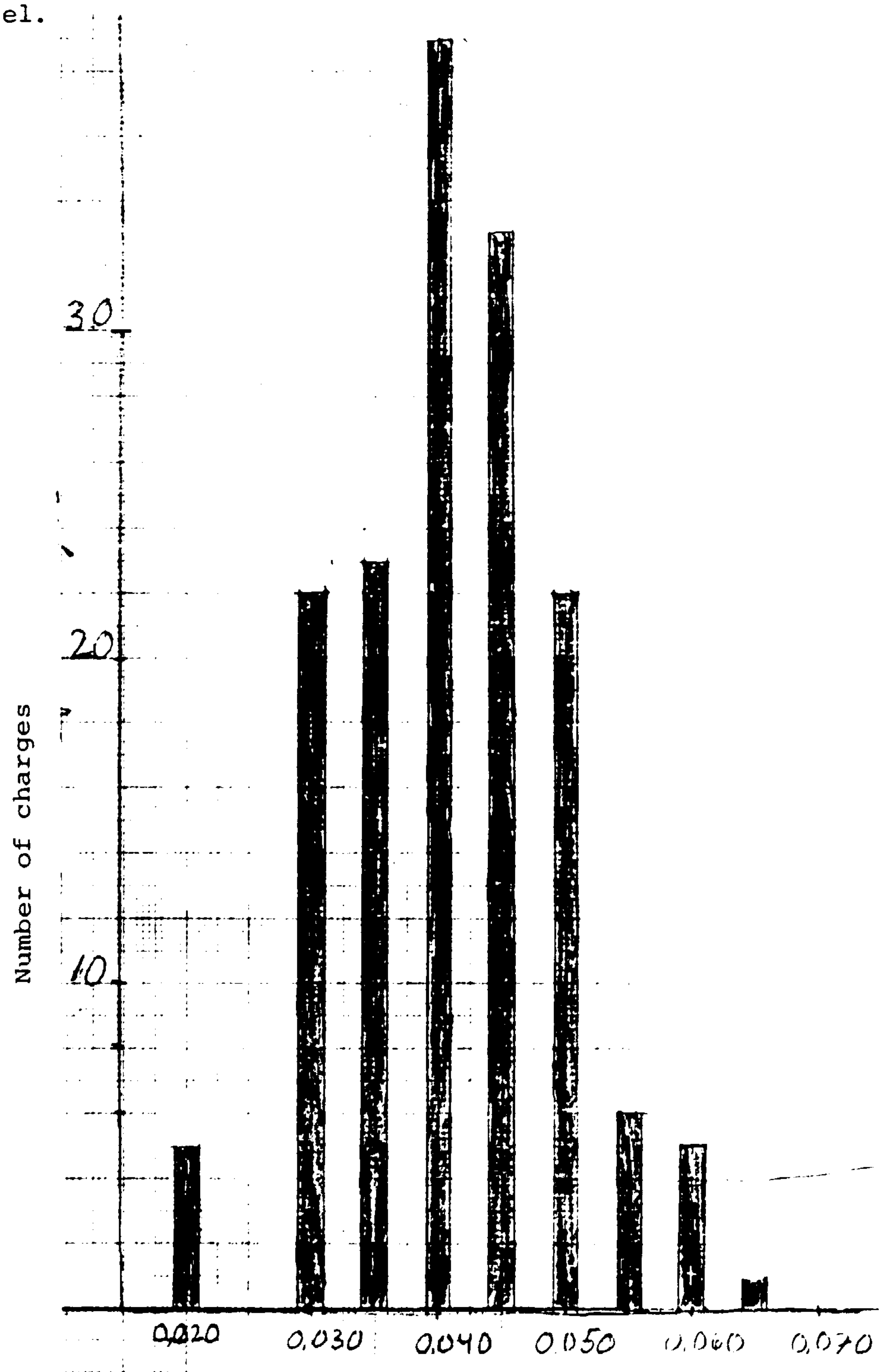

115 ϕ - 2 strands CCM
115 ϕ - 3
130 ϕ - 3
relative crack length (%)
summa P+S+2.7Cu+Sn (%)
1200
800
400
mould life (tons cast)
10
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0
.050
.060
.070
.080
.090
.100
.110
.120
.130

Fig. 16

Often casting speed is fluctuating very much due to blockage of tundish nozzle and is stopped sometimes. This will result in uncontrolled cooling. Similar types of cracks due to S+P may occur due to the above. Fig. 17 shows deviation of S in casts made in May 1981 at Gecosteel.



S-content in steel %

Fig. 17

About 43 % of casts have S-contents more than .040 %. Due to this cracks are caused in billets , so also rolling problems.

Recommendations

a. It is very important to commission a spectrometer as early as possible.

b. Possibilities of having more elements chemically analysed are to be looked into and introduced. This work has been started recently.

c. The scrap must be classified to the extent possible.

2.7 Some special features of steelmaking

The undersigned has already given instructions about steelmaking which are different in some aspects for the present practice of Gecosteel (annex 11). Making steel in this way will give better possibilities to keep in control under the prevailing conditions of Gecosteel. The main points which are different compared to present practice are given below.

a. Before scrap charging in the furnace, sufficient coke (200 kg) is to be added in the furnace, so that carbon in the steel after melting down would be 0.3 - 0.5 %.

b. Limestone must be added at an early stage in a large quantity, before all charge is completely melted.

c. Sufficient reduction of slag must be made with CaSi and carbon powder. Primary deoxidation in furnace with Al is to be done.

d. Al-addition in ladle is not normally made, if needed small quantities should be added.

2.8 The steelmaking problems at Gecosteel are given in short below

a. Insufficient control in operation in all stages.

b. Scrap availability is poor in both quantity and quality.

c. Schooling and training of new personel is not available in practical level and if available, it is poor.

d. Process technical development is absent and proper quality control is not available.

e. Hardly any literature for steelmaking.

f. Due to language problems, instructions and technical papers in English or German are normally not read by the persons concerned. Translation facilities to Arabic are to be provided.

g. Due to lack of proper quality control correct feedback information from casting and rolling is not possible to obtain.

h. Marking of cast No on billets is not the practice here, and hence it is not possible to link up rolling and tensile test results with steelmaking.

i. Analysis of steel is difficult due to spectrometer.

j. Chemical analysis methods are not yet sufficiently developed though in progress.

k. Lime (CaO) is not available. Limestone ($CaCO_3$) is used hence desulphurization in furnace is difficult.

l. Maintenance and repair of equipment are taking much time. Mostly only break down maintenance is made.

m. Handling of refractory material is not good. Maintenance of lining is not being done properly. Sometimes the quality of refractory material is bad and not suitable for use.

3. Continuous Casting

The main task assigned to the undersigned was to investigate the problems faced continuous casting plant and to make necessary improvement proposals. The problems of continuous casting recently at Gecosteel, are mainly due to problems in steelmaking. Hence I have dealt more comprehensively with steelmaking and steel quality necessary for continuous casting.

Lack of gasstirring has caused a lot of problems with continuous casting. Hence gasstirring is dealt with here also. As schooling and quality control are poor, these are dealt with here.

Schooling and training for some key persons are now being arranged under Unido Fellowship programme. Within the framework of my assignment several reports concerning problems and proporsals for improvement have been made by the undersigned. A list of reports are found in annex 12. Some reports are enclosed in this report. Gecosteel will translate these reports into Arabic.

3.1 Gasstirring in ladle (gasrinsing)

The importance of gasstirring is mentioned several times before in the reports. Hence it is now dealt with in some more details. Gasstirring is of special importance to Gecosteel as control of the ladle temperature is difficult and the temperature usually is too high and due to many slag problems. It is also stressed earlier that gasstirring is a solution for temperature control here.

3.1.1 Ladle temperature before gasstirring

Factors affecting the ladle temperature are:

a. The steel temperature in the furnace

b. The tapping time (size of tap hole)

c. Preheating of ladle

d. The quality and condition of the ladle lining

e. Insulation powder on steel surface in the ladle or ladle cover

f. Transportation time from furnace to gasstirring place.

3.1.2 Ladle temperature before casting

As it is difficult to control conditions realized above (3.1.1), the ladle temperature is kept at 10-20^{o}C higher than what it is supposed to be before casting. The temperature in the ladle can easily be reduced by blowing nitrogen or argon through porous bottom brick or rinsing stopper.

3.1.3 Performance of gasstirring

If the aim of gasstirring is only reduction and uniformity of the temperature, then the use of stopperrod system is simple and reliable. If degassing and precipitation and floatation of slag also are required in addition, then the use of bottom blowing may be more effective. Gas bubles are small and stirring of the bottom area is more effective due to bottom blowing. It should be mentioned that porous stopper heads are available for stopper stirring to get smaller bubles.

More care is required with porous bottom brick system. Otherwise there is a risk for breakout in the ladle at the porous bottom brick area, which will be disasterous. In Fig. 18 it can be seen the brick in the ladle bottom and in Fig. 19 more detailed illustration of the bottom brick.

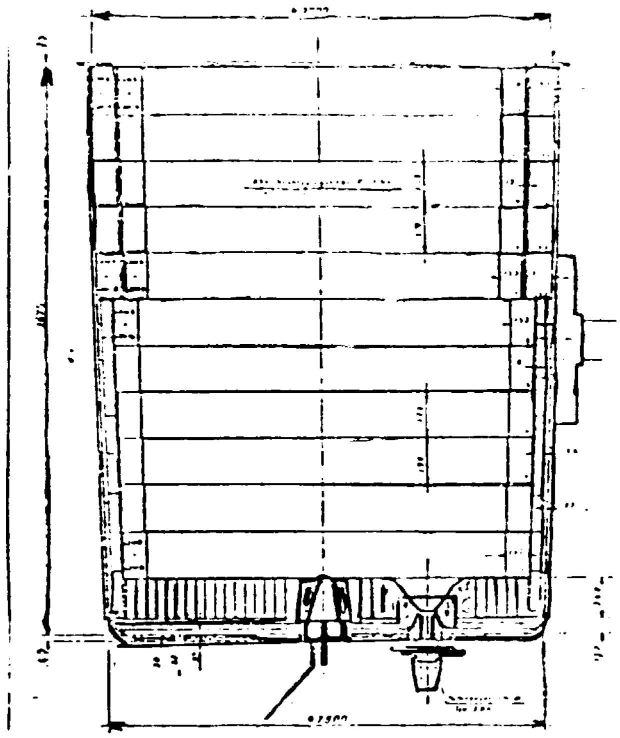


Fig. 18 Ladle for bottom rinsing

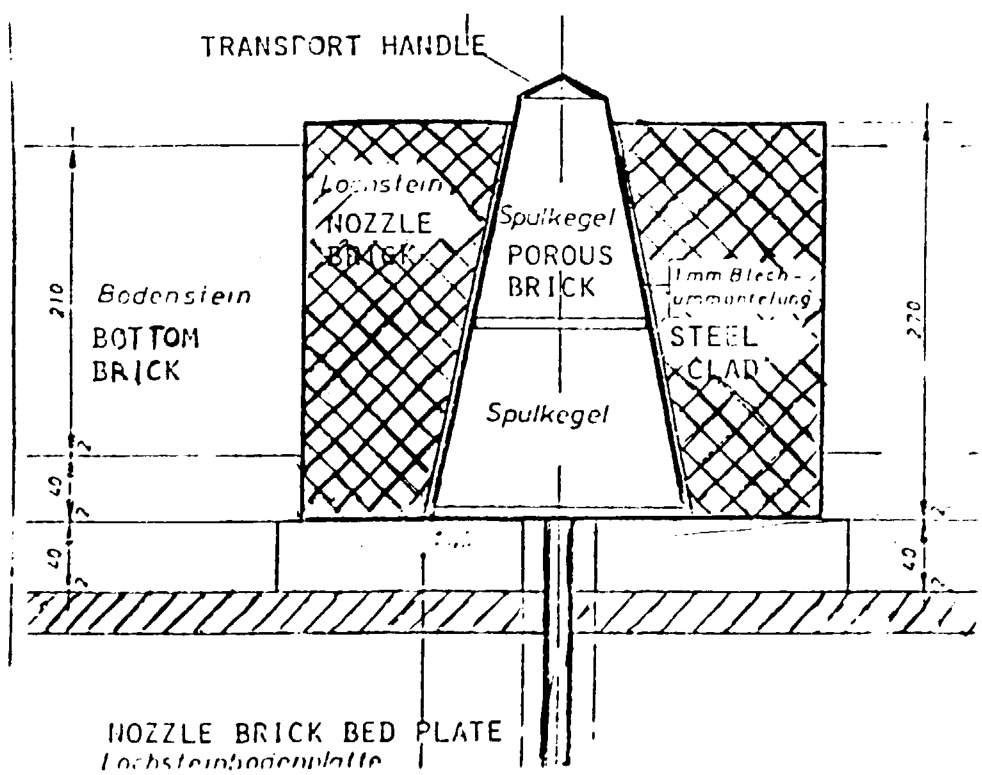


Fig. 19

Nitrogen is normally used for temperature egualising in gasstirring (stirring time is short and the gas quantity is small). Oxygen content of nitrogen for gasstirring should not be very high, otherwise besides reoxidation nitrogen content also will go up in the steel. For gasstirring of some special steel, when stirring time is long and the gas quantity is large, it is better to use argon. Fig. 20 shows a gasstirring station. The station consists of the following parts:

1. Level indication of steel
2. Sampling device
3. Device for measuring of temperature and oxygen activity
4. Slag or bloom to be inserted to the cool steel
5. Stopper rod for gasstirring
6. Device for Al wire feeding

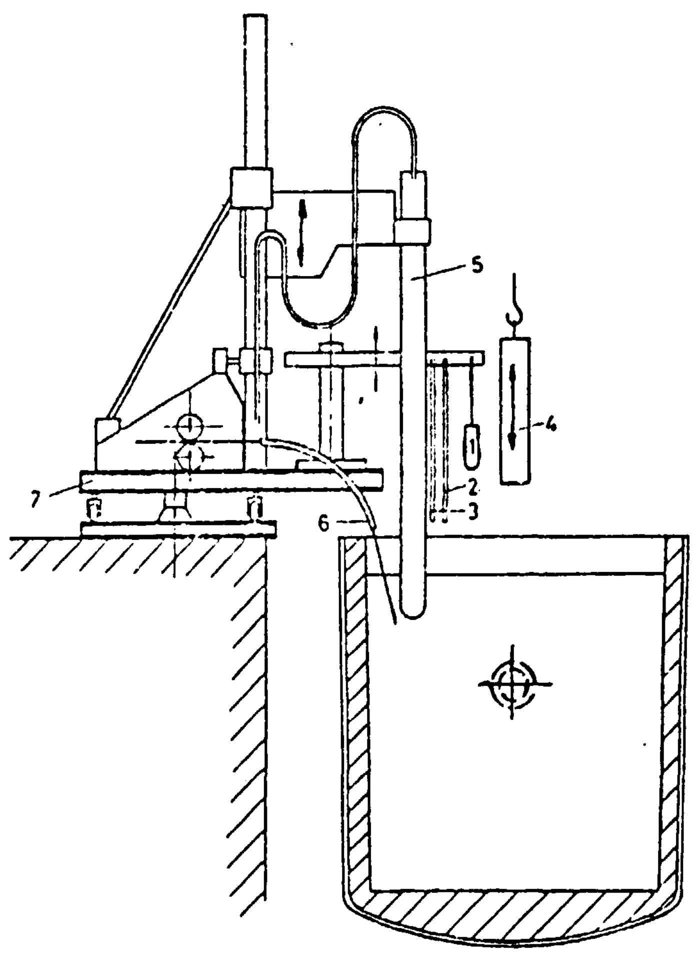


Fig. 20 Gasstirring station

Gasstirring station with stopper is suited to Gecosteel because of operation reliability. This station can be much simpler for Gecosteel. Stopper rod with hoisting arrangement is all required. (Fig. 21)

Temperature can be measured as it is being done now, for cooling light scrap can be used and the stirring gas will obviously be nitrogen.

Undersigned will send a detailed description of a simple gas stirring station to Gecosteel. The stopper rod can be stationary and the ladle can be brought by crane to correct position. This type is mostly good enough for making single castings.

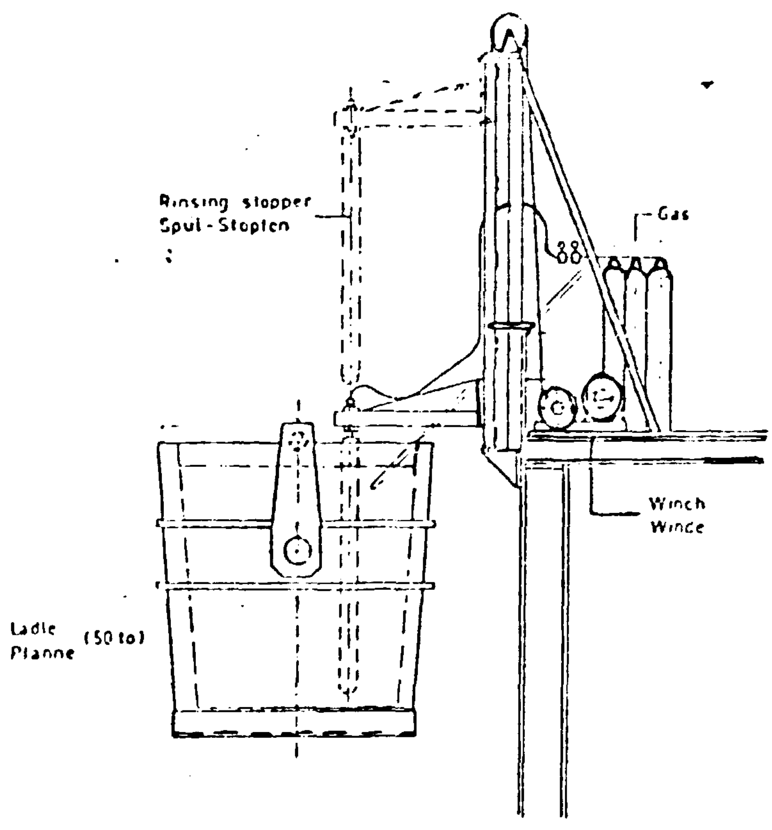


Fig. 21 Stopper rinsing device

For sequence casting although, this will be sometimes to slow. Normally we are assuming that gasstirring has got one main task of temperature egualising, but it has also got some other influences. These are as follows:

a. Egualising of chemical composition of steel (Fig. 22)

b. Quickly melting of alloy elements, deoxidation agents and cooling scrap if added in the ladle.

c. Improving of steel cleanness (Fig. 23)

d. Reduction of bottom skull in the ladle

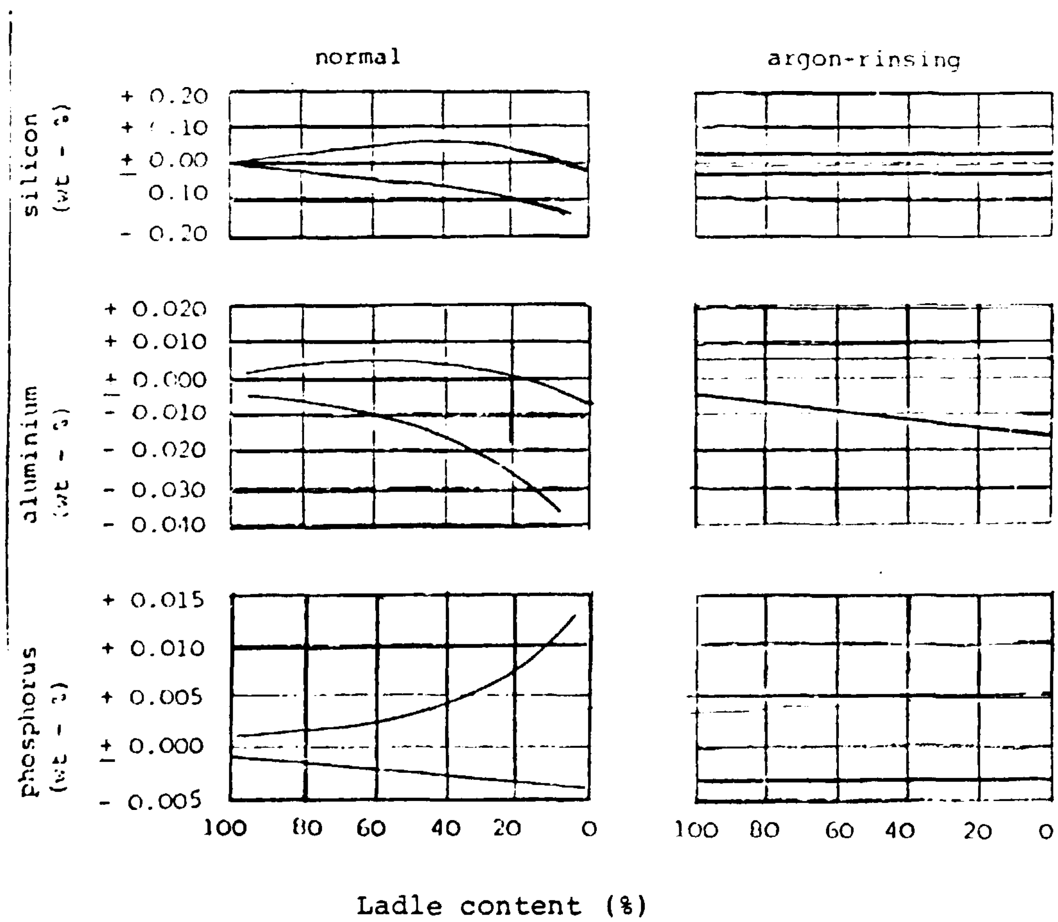


Fig. 22 Variation of analysis as a function of the ladle content for normal and rinsed heats.

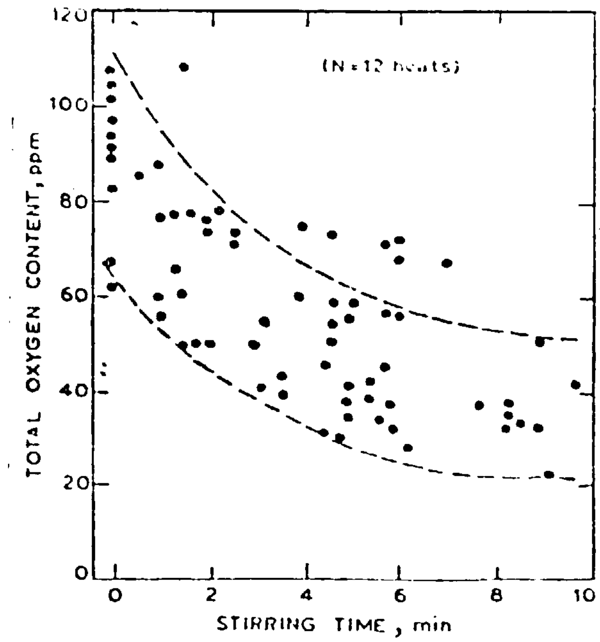


Fig. 23 The effect of Ar-gas rinsing of total oxygen content of molten steel

For gasstirring it is important that large quantities of slag are not on the steel surface in the ladle. Otherwise slagg will react with steel and refractory material resulting in an increase of P and a decrease of Al. In case there is a large quantity of slag in the ladle, the situation can be improved by adding lime (CaO) fines before gasstirring. Fig.24 shows that steel temperature in the tundish with gasstirring is more uniform during the entire time of casting compared to the corresponding one without gasstirring.

The latest developments are preassembled sets of porous bricks and nozzle bricks (Fig. 19), reducing the risk of operational mistakes. In this case also the former bayonetlock is replaced by a nozzle brick bed plate, which is welded to the ladle bottom after mounting the set. The refractory quality is aimed at gaining the same life as the ladle bottom. (This bottom brick system should be suited for Gecosteel too).

In any case, some other operational points have to be considered:

- there should be a minimum time of dwelling (5-10 minutes depending on preheating) for the ladle-lining to reach a stable temperature condition

- the rinsing should be limited to at minimum 3 minutes and at maximum 10 minutes.
  Below 3 minutes rinsing, no representative values (e.g. homogenization) can be obtained.
  Above 10 minutes rinsing, a silicon loss and a phosphorus pick-up (due to phase reaction slag steel) may be excessive,in particular when furnace slag has not been held back completely.

- the whole operation should be rather gentle to avoid slag-steel reaction and reoxidation, respectively reduction.

- in case of stopper rinsing the maximum distance stopper head to bottom of ladle should be 250 mm; the distance ladle wall to stopper should be 0.3 to 0.5 times the ladle radius, to give an optimal flow pattern.

- a possibility of quick change of stoppers at the station is necessary in case of stopper failure.

- the gas consumption rate should be in the range of about 100 - 200 l /min at a pressure of 2-4 bar.

Finally it should be mentioned that Gecosteel can make a simple gasstirring station themselves without large investment costs.

BRICKS	
2 P 24 = 21 2 P 10 = 28	8
2 P 24 = 21 2 P 10 = 27	7
2 P 24 = 22 2 P 10 = 28	6
3 P 20 = 40 3 P 10 = 18	5
3 P 20 = 40 3 P 10 = 17	4
3 P 20 = 41 3 P 10 = 15	3
3 P 20 = 42 3 P 10 = 14	2
3 P 20 = 42 3 P 10 = 13	1

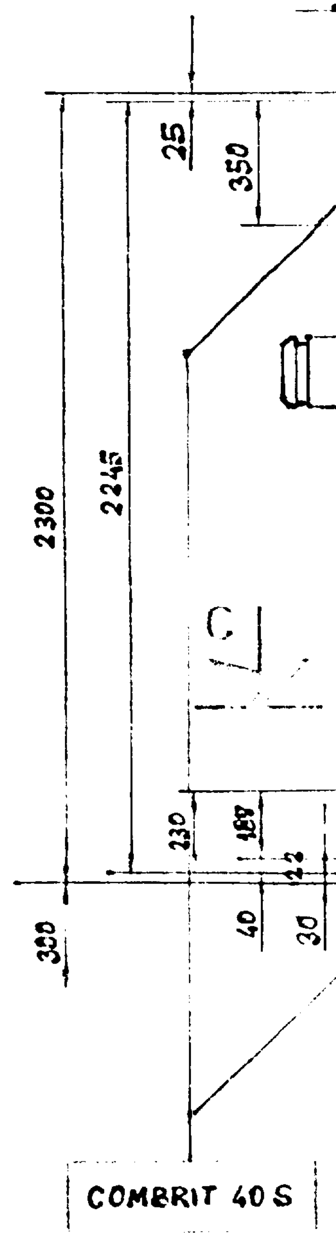
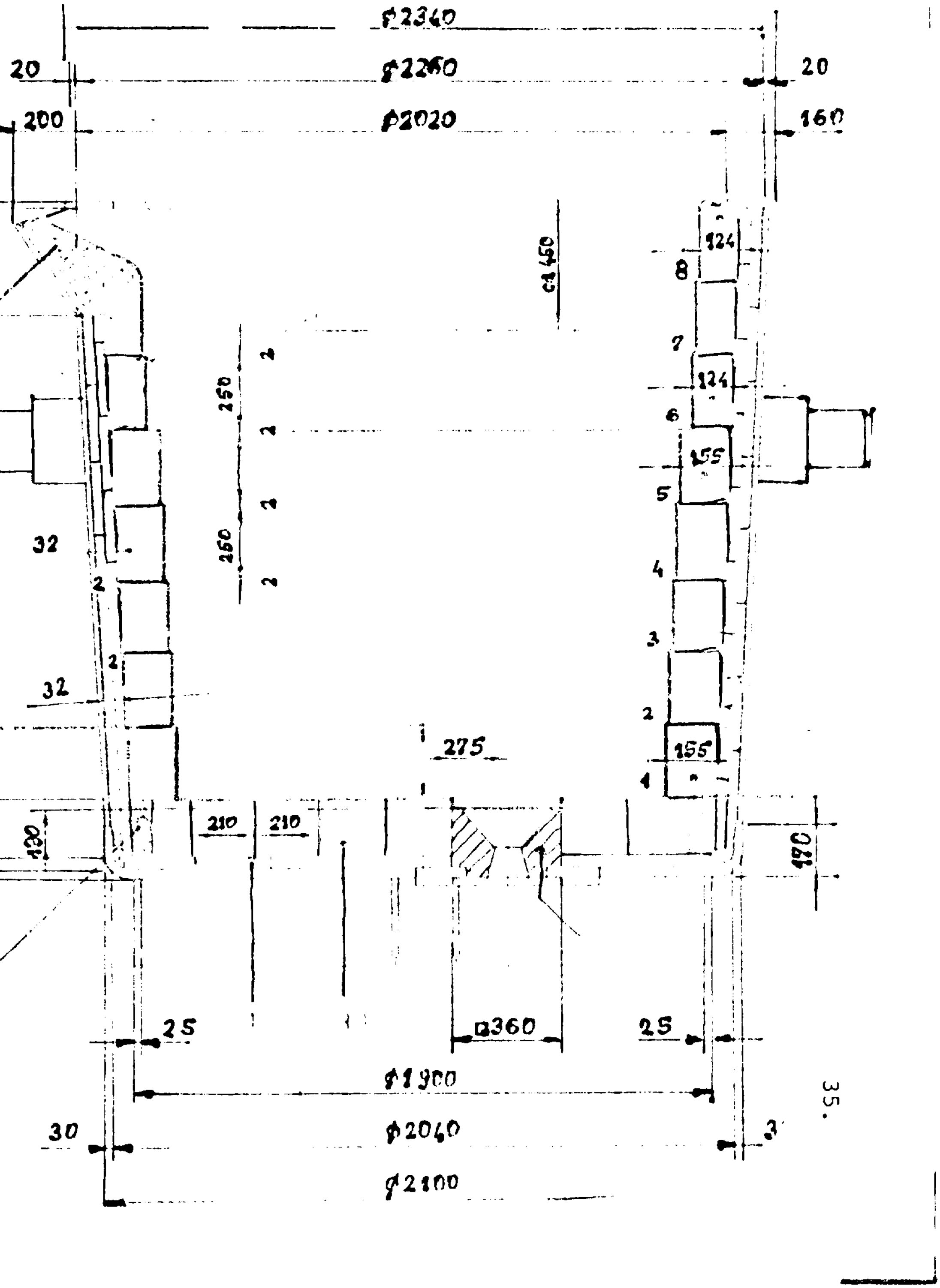


Fig. 24


ϕ2340
20
ϕ2260
20
200
ϕ2020
160
124
8
ca 450
7
124
250
6
155
5
32
260
4
2
3
2
32
2
155
1
275
210
210
180
480
25
□360
25
ϕ1900
30
ϕ2040
ϕ2100

3.2 Continuous Casting operation

3.2.1 Maintaining tundish and ladle lining

For ladle lining fireclay (chamotte) quality Ao bricks are used (Fig. 24). Lining life for this kind of ladle and material in a continuous casting operation is normally 18 to 20. At Gecosteel it is lower, about 10. The main causes of low lining life are:

a. Very high steel temperatures and sometimes partially deoxidized steel

b. Sometimes lining is not made correctly.

c. Due to high level of disturbances in casting operation , casting is very often done in one strand, needing longer time. This causes bottom skul in the ladle. Removal of skul can damage lining. Formation of bottom skul can be reduced by gasstirring.

The tundish is covered with carnes insulating tiles and cold tundish practice is used at present at Gecosteel. Only tundish nozzles are preheated. Earlier there were many problems when hot tundish practice was used. Now the performance of tundish lining is mostly good. In some cases insulating tiles were loose at the beginning of cast. Sometimes the impact plate at tundish bottom has also been loose. Due to loosness of plates the casting operations are interrupted as plates come out to the steel surface causing splashes. These problems of loosness is mostly due to neglected preparation of tundish lining. Sometimes steel comes outside the nozzle from the tundish due to bad quality of mortel and workmenship. The biggest problem nowadays is inclined placement of tundish nozzles and incorrect distance between nozzle. All the above cause serious casting problems such as breakouts, interruption of casting due to skul formation in mold, damage to oil plates etc. To prevent such problems a foolproof centering device was made under my instructions.

For centering the tundish is to be lifted from the stand provided for tundish. For correct use of centering device it will be necessary to rectify the defects of all tundishes. This work is in progress. For some time there was troublefree operation, but then the trouble started again even though the system is foolproof. This has happened as centering was not done at all with the centering device. Now the situation is under control but occasionally some problems crop up. Another big problem in casting operation itself is due to bad quality of tundish nozzles. In this connection the undersigned has made separate reports and submitted them to Gecosteel.

a. Errosion of tundish nozzle in Gecosteel 19-12-80 (annex 13)

b. Influence of tundish nozzles upon casting results (7-3-81, 8 pages and 12 annexes)

3.2.2 Control action and preparation before casting

The check lists concerning control action have been made by undersigned and handed over to Gecosteel. The check lists have been translated into Arabic and placed into continuous casting control room, but it was removed by somebody soon after. A new list has not been supplied. Contents of check points have been explained to engineers and foremen. This type of list is perhaps not required after many years of operation experience. But it would be very useful hence so many control points are forgotten and neglected.

The most important control actions before casting and just after starting:

1. Control of ladle preheating
2. Control of sand feeding into sliding gate nozzle before tapping
3. Checking of tundish lining and nozzles
4. Checking of nozzle heaters
5. Checking of emergency vessels
6. Checking of emergency launders
7. Centering of tundish nozzles with moulds before casting and control after starting

8. Checking of mould condition (visually)
9. Control of mould lubrication
10. Control of mould water circuit (sealing of mould)
11. Control of foot rolls and cooling ring below the mould
12. Control of dummy bar head sealing
13. Checking of secondary cooling zone 1 (hoses and nozzles)
14. Checking of secondary cooling zone 2 (hoses and nozzles)
15. Checking of waterflow and pressure of mould cooling and secondary cooling
16. Operational checking of withdrawal and straightening unit
17. Operational checking of intermediate roller table
18. Control of open circuit machine water
19. Control of closed circuit machine water
20. Operational control of shears
21. Operational control of central oil lubrication
22. Operational control of cooling bed abd pushers
23. Checking of tools and auxiliary materials for casting operation

The following are some of the important points concerning the check list.

3. Cont of tundish lining can be done visually. It is to be ensured that the tundish nozzles are open before and after preheating.

6. Immersion vessels are often more than full of steel and other items. Hence the vessels cannot be used for the purpose meant for. Launders must be checked so that refractory ramming is correct and dry. Some castings have to be stopped at the start due to launder being not dry. It is important to check that launders can move between tundish and mould covers.

7. Proper centering is not always done before start of casting.

8. Before checking of mould this must be cleaned properly. Cleaning has been a very big problem.

9. Control of mould lubrication is normally done in continuous casting machines after careful cleaning of mould and oil gap. But here no proper mould cleaning is done and cleaning of oil gap is often neglected. Casting sometimes has started without oil coming to the mould.

12. Control of dummy bar head sealing. This control is sometimes made, but leakage of sealing has occurred. Before casting dummy bar head must be put about 10 cm inside the mould, but variations from 4 to 30 cm has been found. Now this is under control by using simple measuring devices. Before casting there are wire rod pieces (Ø 12-20 mm and length about 200 mm), which should be placed around the anchor bolt in order to accelerate the solidification. It is important to control that wire rod pieces are really used. Because of big transportation problems between the rolling mill and the continuous casting wire rod pieces are not normally available.

13. Checking of secondary cooling.
    Earlier checking was neglected normally, but now the situation has improved considerably.

20. Operation control of shears
    From time to time shears have caused operation problems and sometimes they are not functioning at the beginning of cast. Operation control is normally made, but sometimes neglected.

    Checking of tools + auxiliary material for casting operation:

    This checking is several times neglected and casting is started without necessary tools + auxiliary material, such as oxygen pipes, hammer in area of straightening machine and shears.

3.3 Starting of casting

Starting of casting is one of the most critical phases in continuous casting. We can have many disturbances during starting itself, but often some starting problems can cause troubles during the whole casting. If we must open tundish nozzle with oxygen, nozzle will become easily too big. Now casting speed increases and high casting speed already as such, increases breakout tendency. Because of high casting speed it is necessary to lower steel level in tundish and slag can easily escape from tundish through nozzle into the mould. Due to the slag in the mould many breakouts occure and this kind of breakouts often happens ½ - 2 below the mould.

After oxygen burning shape of nozzle hole is so damaged that the steel stream is flattering and splashing. Because of above mentioned reasons sticking of steel on oil plates and on the top part of the mould occure. Sticking of steel in the mould by higher casting speed causes very easy breakout. Recently many breakouts of this kind have really happened.

More accurately about different starting methods in paper "Influence of tundish nozzle upon the casting results".

We have many different possibilitites to start casting.

1. Open nozzles.

This is the simplest form - but it is nowadays not commonly used (one exception has been Gecosteel, but now moving to better methods is in progress)

2. Blocking the nozzles with asbestos rope and lead.
3. Closing the nozzles with an asbestos plate
4. Closing the nozzles with a steel plate (used recently in some extent at Gecosteel)
5. Aspestos plug (trials at Gecosteel)
6. Copper plug + sand. The method is used at Gecosteel.

It should be mentioned that for some months ago only open nozzle method with all its disadvantages was used, but now copper plug and steel plate method are in common use. (One reason why breakout rate has gone down).

Immediately after starting it is very important to control secondary cooling so that the system is functioning properly and correct water is flowing. Sometimes this has been forgotten and breakouts have occurred. Another important point is to see that strand comes out from straightener properly. If strand comes out bent from straightener due to uneven or/and too strong cooling, this is to be rectified by hammering with about 10 kg hammer. The hammer is not usually available in the area of continuous casting, but this is an essential item of tools and accessories for casting. This is included in the checklist required before start of casting and it should be ensured that the hammer is available at site. Many times casting is stopped because a big hammer is not available at site. In annex 14 an example to get over the problem is given.

3.4 Performance of casting

If all control points are taken care of before casting and starting of casting is without disturbances, then casting itself may be good. During casting each operation person has to control and follow according to his responsibility. The control points vary according to machine type, steel quality and automation provided. Regarding control points, instructions are normally made so that each individual is assigned certain tasks and responsibility. It is important to make out such instructions along with foremen and workers so that these are realistic and can be implemented easily. The most important points to be followed by Gecosteel are:

a. Temperature in tundish during casting
b. Control of casting speed
c. Casting stream
d. Mould lubrication
e. Control of steel level in mould
f. Control of steel level in tundish
g. Control of condition of ladle and tundish
h. Control of secondary cooling water flow through measuring instruments and visually through inspection holes of cooling chamber

i. Operational control of straightener shears and cooling bed
k. Sample taking and visual control of billet quality.

Maintenance of tundish temperature during casting is very important and is dealt here more in detail. The undersigned has already made a report "Investigation of temperature in ladle and tundish at Gecosteel", annex 15. Tundish temperature must be taken at least 2-3 times during every casting for example 5 min (30 min) and 60 min after start of casting. If the temperature goes down below normal more temperature measurements are required. It can be seen from fig.25 that gasstirring has a beneficial effect on the tundish temperature. Fig. 25 shows the records of tundish temperature in one Spanish continuous casting plant without gasstirring and with gasstirring.

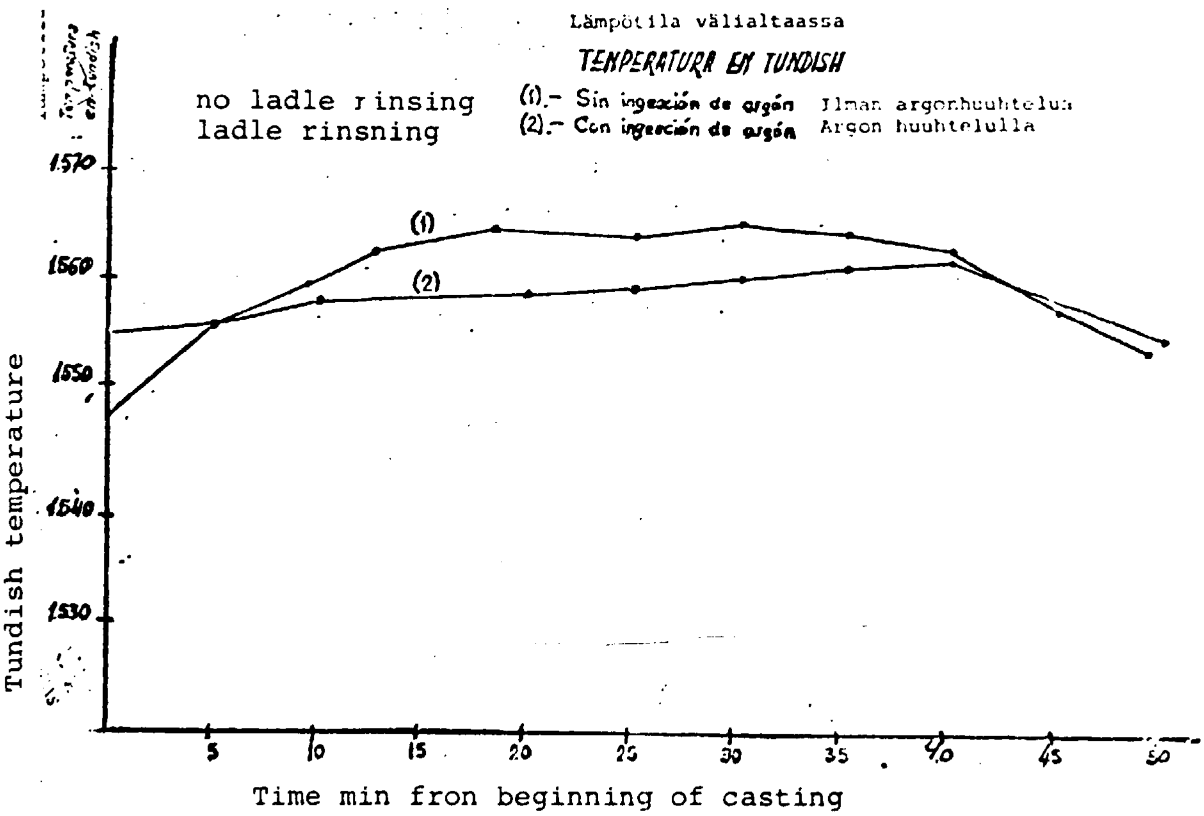


Fig. 25

In fig. 26 similar records from more comprehensive investigations in another plant are shown. In order to forecast tundish temperature, it is necessary to know accurately the temperature drop between ladle and tundish. Fig. 27 shows the beneficial effect of gasstirring on temperature drop between ladle and tundish.

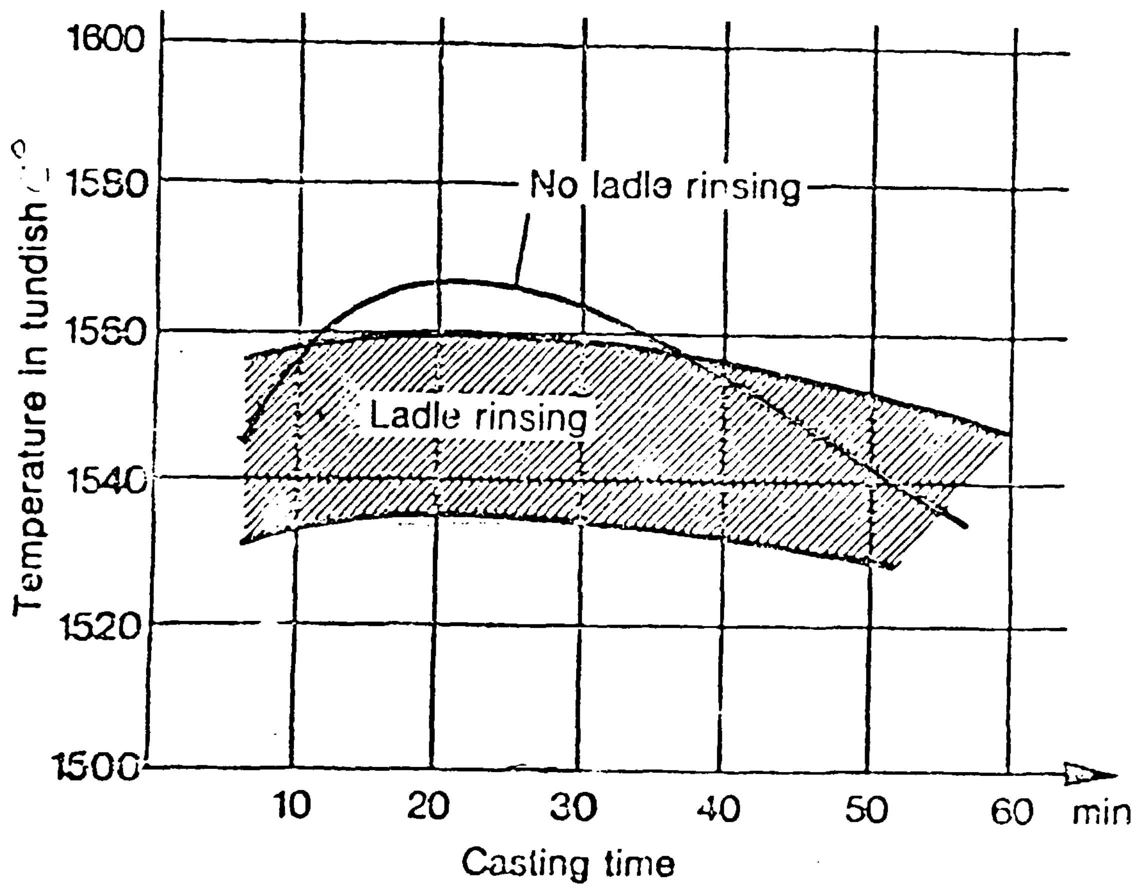
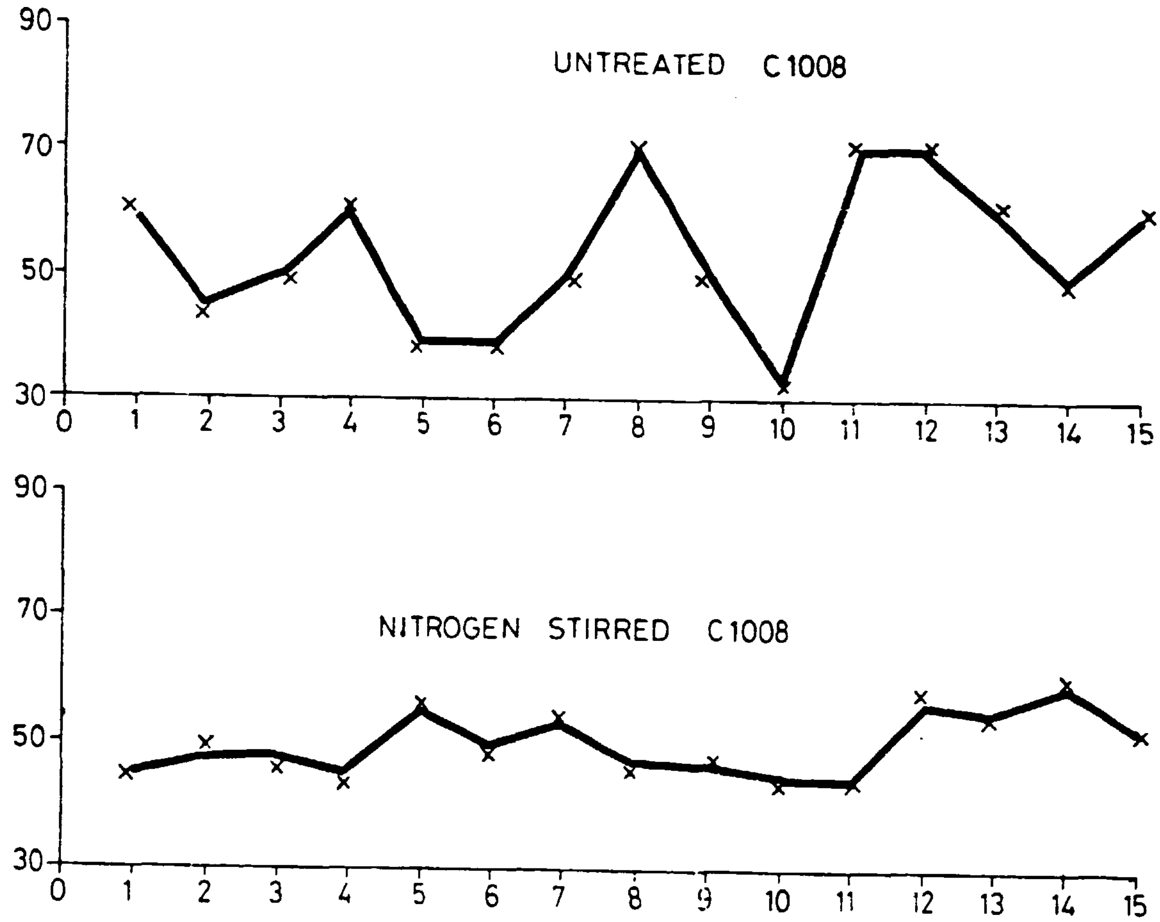


Fig. 26



7 Examples for temperature drop between ladle and tundish in case of untreated and nitrogen stirred steel.

Fig. 27

3.5 Casting disturbances

A report (Possibilities to improve production in continuous casting plant at Gecosteel of 4-12-80) has been submitted by the undersigned. An abstract is given below.

"A systematic and detailed analysis of problems causing low production level has to be made before bigger changing of maintenance and operation systems are possible . This kind of analysis is impossible to make by means of present casting reports. It is only possible to give a list of different disturbances, but not to tell how much production time has been lost. To solve this problem we can use similar form like in Koverhar in Finland (Fig. 28 adaptation for Gecosteel). This form is very easy to fill up. In the following list we can see code numbers of different disturbances. It should be mentioned that we need only 1 report/shift. Before starting to use disturbance time report we must take one or two men from every shift who speaks little English or German and give a short introduction course. Later it is possible to translate the report and code list in Arabic.

Continuous casting time-disturbance report

Date	Shift No	Shift foreman Foreman

Remarks according to disturbance										
Disturbance NO Duration time min										
Machine I	1									
	2									
Time	07	08	09	10	11	12	13	14	15	
	15	16	17	18	19	20	21	22	23	
	23	24	01	02	03	04	05	06	07	
Machine II	1									
	2									
Disturbance NO Duration Time min										
Remarks according to disturbances										

Fig. 28

Code numbers for different disturbances

Maintenance disturbances

1. Pumps for secondary cooling
2. Water treatment for secondary cooling
3. Water circuit for mould cooling
4. Moulds
5. Foot rolls and cooling ring below the mould
6. Water jacket of mould
7. Cooling chamber steem exhaust system
8. Casting crane 1
9. Casting crane 2
10. Billet crane 1
11. Billet crane 2
12. Withdrawal and straightening unit mechanics
13. Withdrawal and straightening unit drivers
14. Withdrawal and straightening unit hydraulic
15. Intermediate roller table
16. Discharge roller table
17. Short end pinch roll set
18. Dummy bar storage device
19. Hydraulic for pushoffs
20. Cooling bed
21. Mechanical continuous casting shears, mechanics
22. Mechanical continuous casting shears, hydraulic control
23. Dummy bars
24. Mould drive
25. Strand guides in secondary cooling chamber
26. Lowering mechanism for strand guide changes
27. Mould lubrication
28. Control oil lubrication system
29. Control grease lubrication system
30. Measurement and regulation instruments
31. Tundish
32. Tundish car
33. Tundish nozzle heaters

Operational disturbances

a. external disturbances

34. Steel returns to melting shop: low steel temperature
35. Steel returns to melting shop: problems with sliding gate
36. Steel returns to melting shop: too much Al,blocki g of nozzles
37. Steel returns to melting shop: bad deoxidation boiling in mould
38. Steel returns to melting shop: some other reason
39. Electric power stop outside continuo ıs casting
40. Shortage of auxiliary materials
41. Waiting for steel

b. internal disturbances

42. Shortage of tundishes
43. Mould change
44. Change of strand guid in secondary cooling chamber
45. Breakout repairing in cooling chamber
46. Repairing of machine for next casting
47. Steel returns to melting shop depending on operational mistakes in continuous casting plant
48. Other internal disturbance

This was a good idea but due to implementation difficulties and lack of capable engineers, this could not be carried out. But it is hoped that this system of making reports will be put in use.

This report is not only to control production but is also necessary for planning maintenance. As making analysis as per report is not possible ,the undersigned has made some kind of disturbance report every month. This report is based on available reports of continuous casting and my personal observations in the plant.

The statistics concerning disturbances are not quite reliable because of negligent filling of casting report. It is necessary to pay direct attention to this matter. Because of low production level the foreman has enough time to make the report. Annex 16 shows disturbance report of March 1981 and annex 17 shows list of disturbances in May 1981.

Generally it can be said for these reports that the main disturbances are due to breakouts. During the last two months disturbances due to bad steel quality has increased considerably. But the breakout rate has gone down continuously. The breakout rate in May was 4.9 % whereas it was 10-15 % earlier.

Mechanical disturbances are not very dominant, but shears have interrupted casting from time to time. Sometimes electrical disturbances have also occurred. Due to improper functioning of equipments, some other disturbances are caused, but these are not brought out in the casting report because these are indirect.

In the report made by the undersigned only direct cause of disturbance has been taken into account. Concerning breakouts a separate report has been submitted earlier. (Actions which can reduce essentially the present high breakout rate in continuous casting plant at Gecosteel 13-12-80). The main breakout causes only are dealt with in this report.

a. Too high steel temperature and often at the same time poor steel deoxidation or/and too much slag in steel.

b. Too hard mould cooling water (this has now been solved, when water softening plant has been started again).

c. Starting breakouts due to melting of dummy bar heat bolt an account of high steel temperature (this can be prevented by putting cooling scrap in the mould before starting).

d. Inclined steel stream into mould

e. Uneven and sometimes insufficient secondary cooling just below mould

f. Human error.

g. Uneven and insufficient mould lubrication.

This type of report is not suffcient but is better as nothing is made at present.

It is very important to introduce the system of report as mentioned in the beginning, depending on such introduction. The system of reports which have been made by the undersigned should be continued.

3.6 Production statistics

As mentioned earlier, the undersigned has made monthly reports where production, yield and breakout rates have been dealt with. These three factors have indicated good picture of the situation in the plant.

3.6.1 From Fig. 29 it can be seen that the production has increased from level 2500 tons/month average during the last 2 years to 3550 tons/month during the 5 first months of 1981. The best production of 4700 ton was achieved in March 1981. During the last few weeks production has gone down due to lack of scrap in quantity and quality. At times scrap availability was only for one furnace operation. This has got a strong effect on quantity and quality of the steel produced during the period. Non availability of spectrometer has also effected the production. In spite of problems it should be possible to produce 5000-6000 tons in continuous casting plant each month if only adequate amount of castable steel is fed to the continuous casting machines. With a minor change and improvement in operation and maintenance the production level can be increased to 7000 tons/month. A normal production of 10000-12000 tons/month is not possible without going deeply into the problems of preventive maintenance, spare parts availability, schooling of personel and their aptitude to work and incentive.

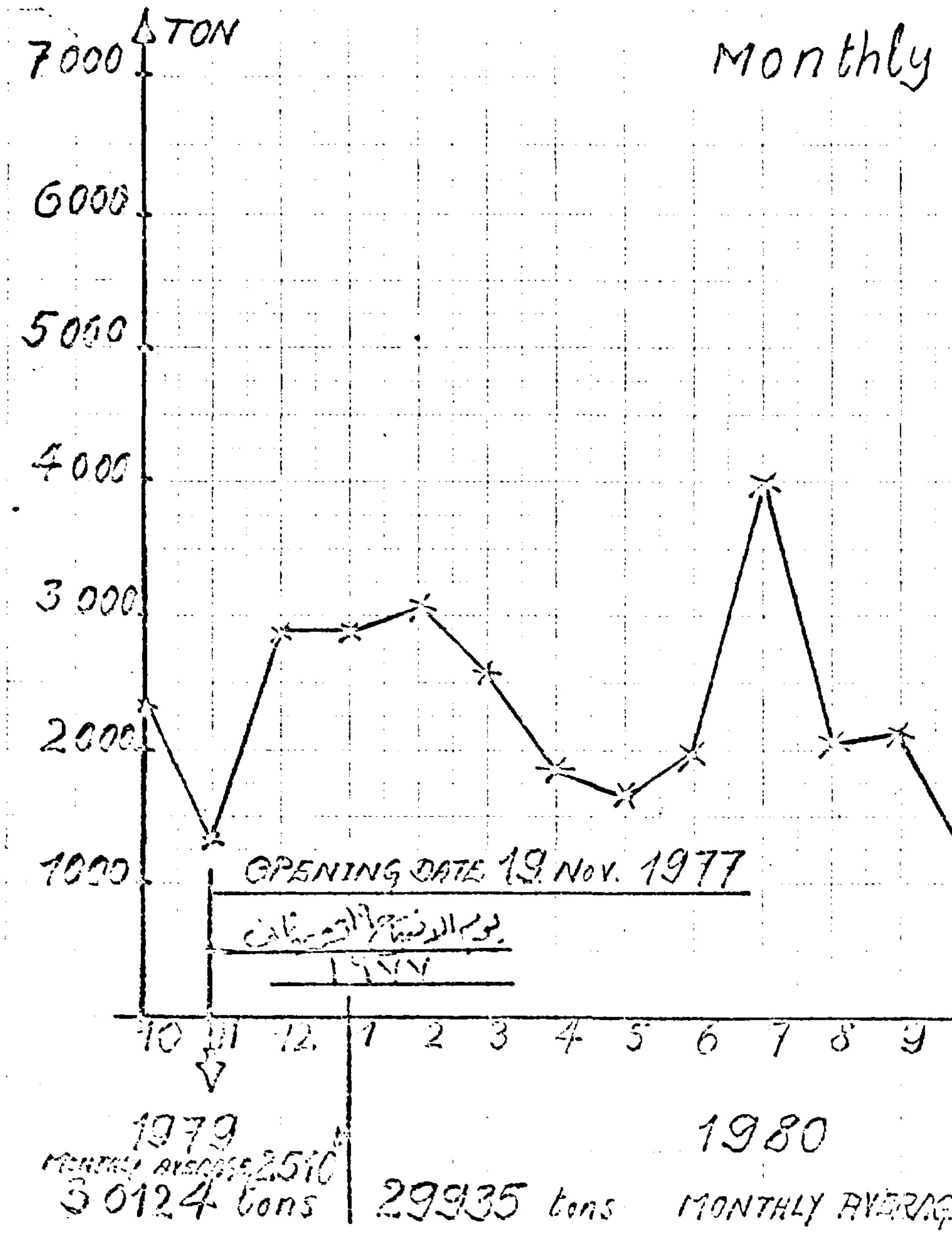
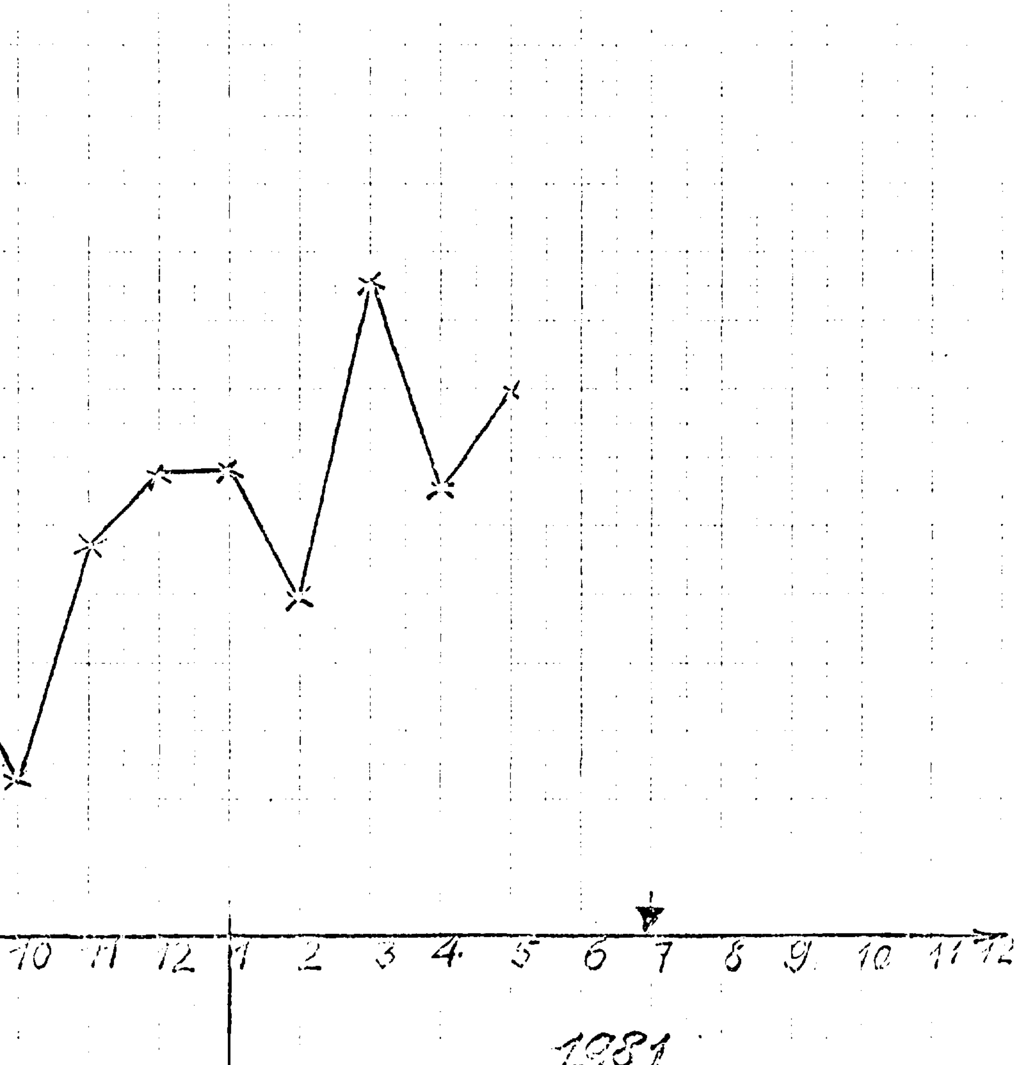

Monthly
TON
7000
6000
5000
4000
3000
2000
1000
OPENING DATE 19 Nov. 1977
١٩٧٧
10
11
12
1
2
3
4
5
6
7
8
9
1979
2510
30124 tons
1980
29935 tons
MONTHLY

Fig. 29

billets production by Geosteel.



E 2495 tons | AVERAGE OF THE FIRST 5 MONTHS 3550 tons.

3.6.2 From fig. 30 it can be seen that breakout rate has gone down considerably from level 10-15 % to 5 %, satisfactory under the present conditions. The reduction in breakout rate depends on:

a. A little bit better temperature control than earlier

b. Improving of starting technics of casting

c. Better control of mould

d. Improvement made in secondary cooling system

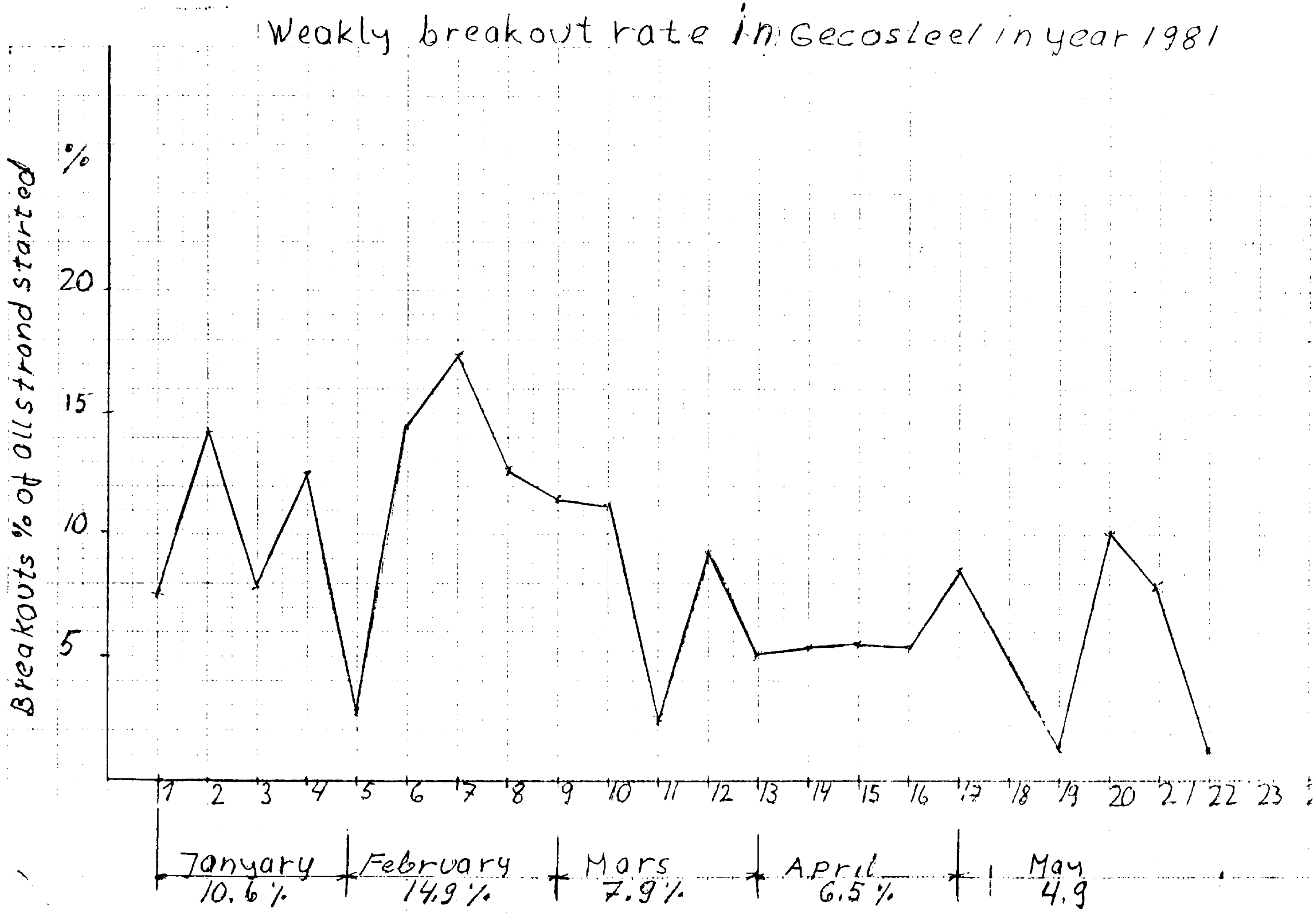
e. Quantity of badly deoxidized steel is decreased (Problems are now blocking of nozzle and more slag in steel).

f. Important reasons of less breakout rate are improvement of operation technic in spite of various problems and not many problems with mould cooling.

3.6.3 <u>Yield</u>

Yield (from molten steel to good billets), tells very much about operation level of continuous casting too. Normally yield in similar plants with similar production is about 96 %. From fig. 31 we can see that yield has been normally 80-90 %, but in March during some week 90 - 92 %, which is satisfactory in prevailing conditions. After March yield has gone down due to bad castability of steel. Steel had caused blockage of nozzle and had more slag and sometimes deoxidation is partial. Maintaining of correct casting temperature also had deteriorated. Bad scrap has contributed to this situation, but it is not the only cause. It is necessary to make some changes in steelmaking practice and to take more accurate control action.

Fig. 30



Weakly breakout rate in Gecosteel in year 1981
Breakouts % of all strand started
%
20
15
10
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
January 10.6 %
February 14.9 %
Mars 7.9 %
April 6.5 %
May 4.9

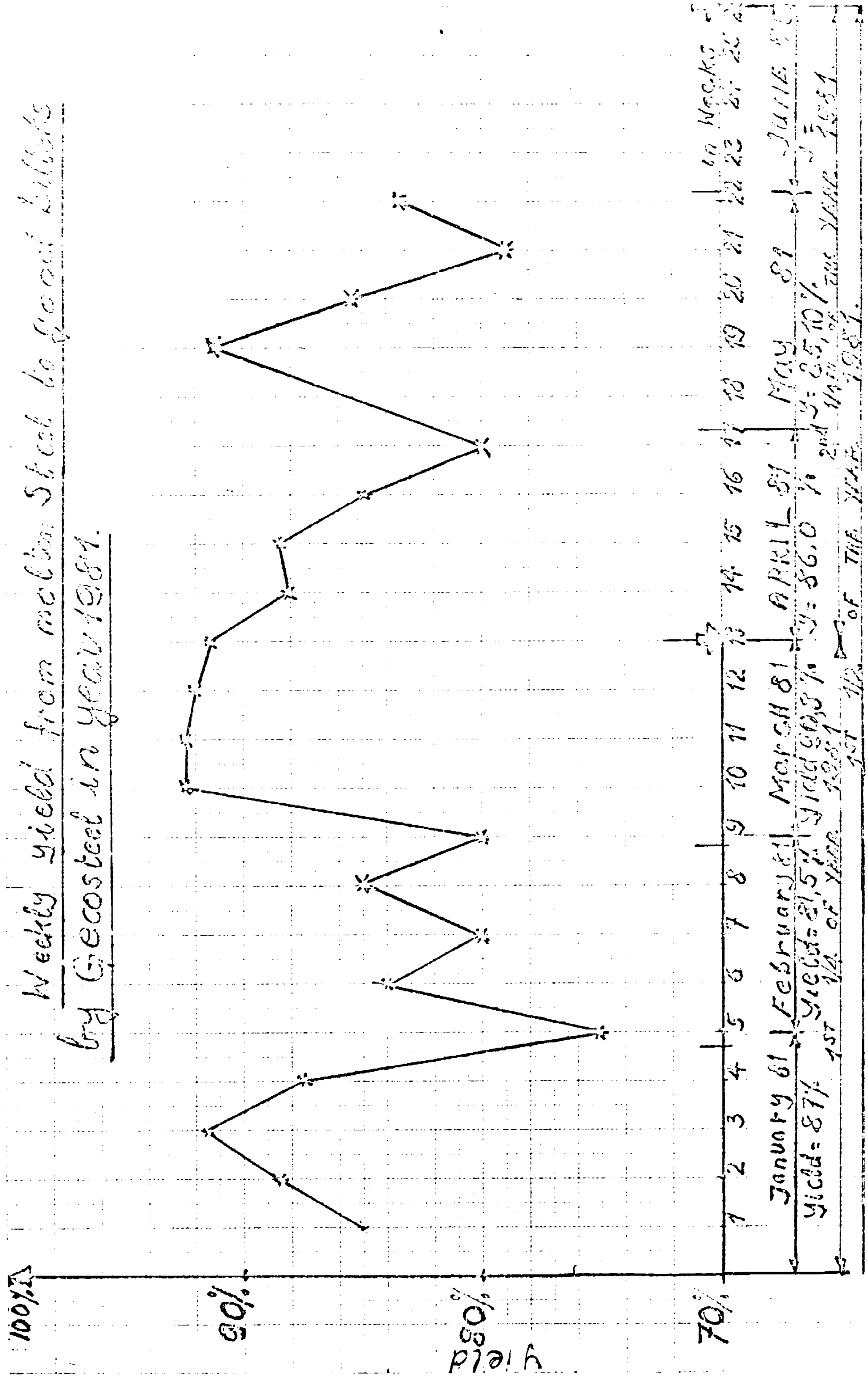

Weekly yield from molten Steel to good billets
by Gecosteel in year 1981.
100%
90%
80%
70%
yield
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 in Weeks
January 81
February 81
March 81
APRIL 81
May 81
JUNE 81
yield = 87%
1ST 1/4 OF YEAR 1981
2nd 1/4 OF YEAR 1981
1ST 1/2 OF THE YEAR 1981

Fig. 31

4. Maintenance

The aspects of maintenance which are directly related to an operation and quality control are mainly dealt with here. This presentation as per requirement of machine construction will make maintenance easier, when evaluating effectiveness of maintenance of some continuous casting plant. Down time of plant due to maintenance is not the only aspect to be looked upon. There is important relation between planned maintenance and unplanned maintenance.

Unplanned maintenance can sometimes be short and maintenance cost may be low, but cost of production loss will be much higher than maintenance cost . In addition it will cause interruption in the production tempo. The disturbance effect may last for a long time. Such breakdowns (unplanned maintenance) must be minimised with following actions:

a. Preventive maintenance of important areas which are liable for disturbances, should be attended frequently based on the disturbance data obtained.

b. Continuous control of machine functions to be watched by operation and maintenance people, so that symptoms of defects before breakdown can be found out. These defects can often be repaired during normal production stopages. (For example preparing time for casting, repair of breakout, mould change etc). The maintenance planning should be flexible so that such types of defect elimination can be included in the planning at short notice.

c. It is necessary to keep ready subassembling and assembling of spares, which can be replaced easily in a short time, so that when symtoms of defects are found they can be attended at short notice.

d. The history of repair of such should be recorded in a suitable form for future guidance, statistics and analysis.

e. Good schooling of maintenance personnel is necessary.

f. On the basis of statistics and records suitable planning should be made for continuous inspection and timely repair in sensitive areas. The improvement sensing should be proper so that production quality does not deteriorate.

Maintenance effectiveness is prerequisite for high production. The undersigned has never come across any continuous casting plant with continuous high production without effective maintenance.

4.1 Maintenance in Gecosteel

There are a lot of different maintenance problems in the continuous casting plant but only some important ones which have direct influence on production are mentioned here.

4.1.1 Tundish and tundish car

Tundish has got distorted during normal worn and timely rectification is to be made. As mentioned earlier the centering device introduced need rectified correct tundish. Transverse movement of tundish on tundish car is very important for centering nozzles with mould before and during casting.Hydraulic adjustment for transverse movement is manual and is not satisfactory.

Preventive maintenance in the hydraulic system should be intensified. The longitudinal movement of tundish car is also not satisfaetory as tracks are bad and cleaning of tracks are not proper. Burners for tundish nozzle heating are often not functioning properly. More effective maintenance of burners and to keep more burners in circulation are necessary. Large size of burners and better types to be used. A large size is important in case of transfering a ladle from one casting machine to the other as preheating time will be less. For troublefree starting effective preheating of nozzle is very essential.

4.1.2 Moulds

The mould is the most important part of casting machine, because the solidification of steel starts in the mould. Many casting disturbances originate in the mould. Undersigned has made a report about mould ("Importance of mould cooling for continuous casting" on 10-5-81), annex 18. In this report the principle of mould cooling is presented. A mould card has been made for recording the history of each mould in casting as well as repair in workshop. The card is included in the above annex. The use of this card has been started, but due to certain problems the card is not maintained properly with relevant details and information. As a result of which the full benefit is not being achieved, some important points about the use of mould as per the above report are given below.

a. The mould must be cleaned , checked, lubricated before the next casting (same way as use of gun).

b. The oil plate of mould are in a very bad condition. Hence more attention is required for the maintenance of the oil plates. Due to distortion of plate , oil comes out instead of going inside the mould. (Concerning mould lubrication and oils used a report has been made and haded over to Gecosteel "Oils for mould lubrication on 25-02-81").

   The repair of plates have been done by welding up and machining the plates and using them with extra packing. The situation has improved but it is not adequate as new oil plates are not available and repair of the used plates takes very long time. Oil plates get damaged due to overflow and disturbances caused by inclined stream.

In Imatra and in Koverhar plants in Finland much better results have been achieved with cast iron oil plates (Fig. 32). These are in use for the last 6-7 years (11 billet strands and 600 000 tons/year). The advantages of such type of oil plates are as follows:

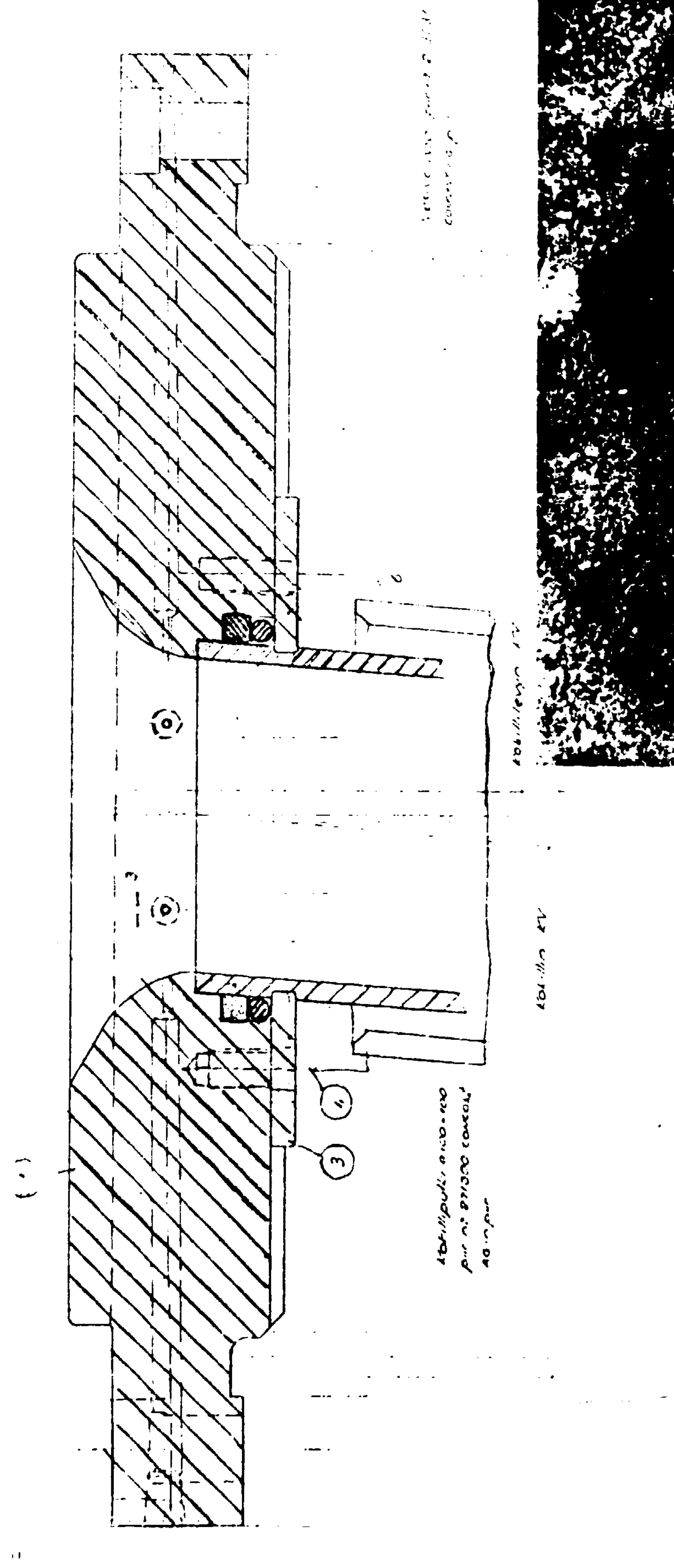


Fig. 32

- Leakage of oil can be prevented
- Sticking of steel in the corner of oil plates is reduced
- Visibility in the mould is good
- Cost of such plate is cheaper than the plate in use at Gecosteel
- It is possible to make such plates here. One such plate on trial basis has been planned and it will be available in the near future.

c. It is necessary to check and rectify the stroke of mould movement at least once per month. Recommended length of stroke for machine 1 (⊄ 100) is about 12 mm and for machine 2 (Ø 80) ca 16-17mm. The stroke value of machine 1 was found like 8 mm sometimes. During the last few months the measurement have been taken in my presence. There are some people in the casting shop and workshop who can take measurements.

   The deviation of mould movement is to be measured from time to time. According to Concast instruction the max permissible deviation is 0,1 mm.

d. Repair of mould and assembling it with assessories must be correct (all facilities for such repair are available). Mould repaired in the repairshop often have leakage in the water seal and mould lubrication systems. The situation has improved to some extent during the last few months.

e. Untreated water should never be used for mould cooling. In October, November and December 1980 as water softening plant was out of order the results were really catastrophic. It can be mentioned that one mould got completely melted. Mould melting may often cause explosion endangering safety of persons working in the area.

In Concast instruction book it is clearly mentioned in English and in German as follows:

"It is most important that the hardness of the mould cooling water does not exceed 2 dH (German hardness)and should preferably be zero hardness with a higher hardness deposit (e.g. $CaCO_3$) on the mould wall will result, leading to overheating of the mould tube and subsequent loss of the copper hardness. The tube will irreversibly deform and breakouts will result. It is therefore essential to check daily the hardness of the mould water if the feed water is known to be hard".

It can be mentioned that in Demags and Vöests instruction books max hardness is 1 dH. After analysis hardness of untreated water used for mould cooling was found to be 4 to 6 dH. When water softening plant has put use again the condition of cooling water is satisfactory. It is essential to check and clean the outer surface of the mould when it comes for repair to the workshop.

4.1.3 Secondary cooling

Secondary cooling system as such is good enough for making ordinary steel St 37, which is not normally liable to cracks. Secondary cooling is often uneven and sometimes insufficient due to misalignment of spraying nozzles and closed nozzles. The situation has improved after some changes.

In the secondary cooling top section corner nozzles normally were not spraying water against corner due to misalignment but against billet faces. As a result of this uneven cooling below the mould took place. In case of breakouts more cleaning is necessary due to corner nozzles. Hence these top corner nozzles are removed and to compensate reduced cooling effect an extra nozzle for each side of the top section and one more size nozzle on each side of cooling ring were added. Bigger nozzles below the mould can be used (Jato 6065 is used now, but Jato 8065 can be used too).

Nozzle pipes were originally connected to the main water pipe by screwed joints and gaskets. These joints were getting loose often during casting disturbing the alignment of nozzle sprays. Now these have been welded to the main pipe and after that the secondary cooling has improved. Repairing of roller aprons of secondary cooling takes unnecessary long time. This mainly due to shortage of spare parts and inadequate facilities in the repair shop. (For example tenplate for nozzle alignment has been ordered for many months ago, but it has not been made)

It is necessary to give serious attention to the problems of spare parts and providing additional facilities. Spare parts required can be made in the workshops, locally in the country. All manufacturing drawings are available. Spares required are mostly rolls, water pipesm nozzle pipes and other simple components.

Recommendations

a. During operation it is necessary to check secondary cooling system after every cast . Closed nozzles must be cleaned and changed. Nozzle pipes which go out of alignment should be rectified before next casting.

   This aspect was not given proper attention earlier. Now the condition is satisfactory but needs further improvement.

b. At least one complete roller apron must be repaired and kept ready. This can be changed during a weekend. After serious breakouts it will also be possible to change the whole roller apron if prepaired apron is available. As the working condition in the cooling chamber is not comfortable the quality of the work is not satisfactory. Unfortunately complete repaired roller prons are not available often and it takes about a week to make one ready. (Normally in Europe it takes 1 day for two persons to repair one such assembly, when spares are available).

4.1.4 Withdrawal straightening machine and mechanical shears

Straightening machine has seldom given trouble here. During the last few months breakouts have occured only twice in the straightening area due to hot shortness of steel and high casting speed at the same time. Different kinds of strand guides between straightener and shears have sometimes caused problems. There has been some electrical disturbances too.

Mechanical shears have caused considerable more problems. These problems are mainly due to lack of preventive maintenance. Generally this type of mechanical shears are reliable if necessary preventive maintenance and checking are done regularly as per schedule.

General

Now when productions is low the condition of the equipment is mostly satisfactory. But when production goes up to ca 6000-7000 ton per month the present maintenance will not be able to follow the increased production. Maintenance time available will be less for higher production.

Now 75 % of the machine time is available for maintenance due to low production,but if effective production time will go up from 25 % to 50-60 % maintenance will not be able to cope with work with less time available with the present resources.

5. Quality Control

Gecosteel has got some organisation for quality control but systematic quality control is not functioning in practical field. If there are serious defects in the billets it can be discussed.

In a few cases bad billet defects are recorded in the casting reports occasionally. Billets are not marked with casting numbers and they are sent to the rolling mill in a mixed pot. (People and time are available for making marks on the billets). It cannot be known billets of which particular cast are causing rolling problems. There is no control of internal structure and defects of billets. Such types of internal defects can easily be controlled with sulphur print and to some extent with ultrasonic (ultrasonic apparatus is available). There is nothing to prevent taking sulphur print and some trials have been made. From the prints internal structures can be seen and some conclusion about effect and eveness of mould cooling and secondary cooling. Fig.33 shows a sulphur print.

C Ca 35 TA 96

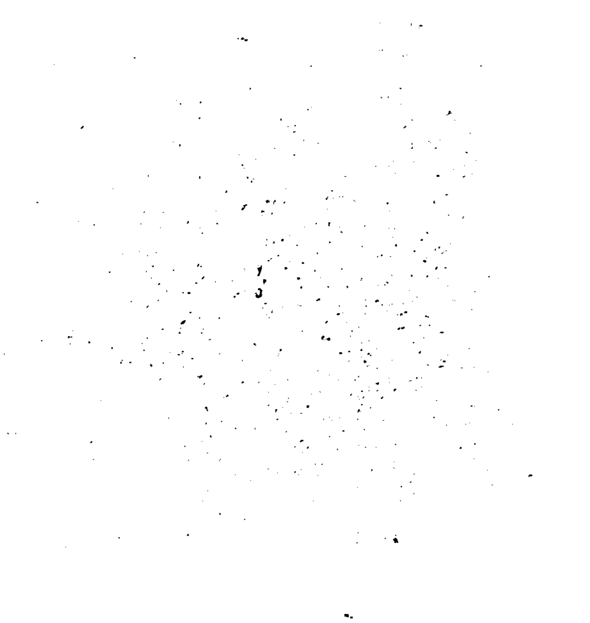


Fig. 33

With an ultrasonic device it has been found that there are cracks and porosity when casting speed and sulphur content are high. The quality level of the billets is now bad. The biggest problems of billets are transverse corner cracks and slag on the billet surface. The rolling mill has a lot of problems in rolling such billets.

Rolling of imported rimming steel has given about 96 % yield. Yield from billets of Gecosteel is only 80 %. Normally continuous casting billets are giving slightly higher yield than rimming steel billets by rolling.

Bad quality of the billets are due to following:

a. Too high casting temperature
b. Too much impurities in the steel
c. Desulphuring is not always taking place in steelmaking due to lack of burned lime
d. Sometimes bad mould or even secondary cooling may cause defects.

The following separate reports made by the undersigned concerning the billet defects and their causes are given below:

Most common billet defects

a. Oscillation Marks

This kind of defects are caused mainly by the following things: Mould movements are not correct.
(Mould orientation could be off center, the mould strip is not correct).

- Uncorrect alignment of the mould with the secondary cooling apron
- Bad mould conditions (deformation).

b. Over lapping (double skin)
Some of the common causes for these defects are:

- Unsufficient and uneven mould lubrication
- Deformation of the mould

- Bad mould surface
- Large quantities of slag in the mould (this disturber lubrication).

c. Slag in the billet surface

The most common reasons for t defect are:

- Oxidation of steel (bad deoxidation practice)
- Reoxidation of casting streams
- Slag formed from unproper tundish materials

This defect can be helped using Nitrogen (Argon) stirring in the ladle, by a stream protection system. A protection system of this kind can be found in one of the OVAKO reports. The steel level in the tundish must be high enough, at least 300 mm.

d. Transversal corner cracks

This type of defect is the most dangerous one during rolling operations, and it is caused by the following things:

- Bad mould lubrication
- Uncorrect mould movement
- Mould deformation
- Unproper tappering of moulds
- High steel temperatures
- Residual elements on the steel (S,P,Cu,Sn)

e. Longitudinal corner cracks

These cracks are not as dangerous as the transversal corner cracks, the principal cause for this defect is the unusual wearing of the mould corners, and on uncorrect mould radius, this defect could be reduced by using Cr plated moulds.

f. Macroslag in the steel

Formation of macroslag can be prevented by:

- Good steel deoxidation
- Aluminium wire feeding in the mould
- Protection of casting streams

g. Internal cracks
Principal reasons for this defect:

- Uneven mould cooling
- Non-uniform and excess of secondary cooling
- The type of steel has great influence on this defect (C=2.0)
- High concentration of residual elements (P,S,Cu,Sn)
- Too high casting temperatures
- Too much pressure on the billet from the withdrawal and straightening machine.

This defect is dangerous if it is located near the billet surface, normally they are welded during rolling, but if the crack number is large a larger amount of deformation is required to weld the crack, minimum deformation without internal cracks is 1/5, and in presence of internal cracks this value changes to 1/8.

h. Central porosity and segregation
Typical causes are:

- Too high casting speed
- Too high steel temperature
- Type of steel
- Uncorrect secondary cooling

Criterion for surface billet conditions

At Imatra, where mainly special steel is made, the following control actions are takne in order to obtain a good billet quality.

- One Bauman print from every line and every change
- Inspection of cutting faces, results are found on several casting reports
- One billet from every line is analysed using grinding tests.

(One mm is grind off the surface and the number of different defects is counted.)

After results are obtained the billet handling department, makes a decision about the billet conditions. If the surface quality is bad, and there are no internal cracks near by the surface we are making a total crack. If the billet quality is good we must have a visual inspection on every billet and removing of all possible defects with spot grinding.

In Koverhar, where we are making mainly merchant steels, we have no billet inspection for this kind of steels. In the case of wire roll, we have the following control steps, a piece of 400 mm is out for surface pickling, inspection or a whole billet is taken from every line, the billet is sent blasted, and a close look control is kept on the results. If the results are good, there is no more inspection on these lines. In case the test sample is in bad conditions (usually transversal corner cracks), then the whole line is inspected and conditioned by a special working line. Billet feeding, shot blasting, visual inspection, removing of defects with hand grinding.

Recommendations

a. An experienced engineer must be put in charge of quality and development of process technic. Process technical development aspects have been stressed earlier in different connections in this report. Without quality control it is not possible to have process technical development.

b. Laboratory should make sulphur prints.

c. Visual control should be made for cutting face and billet surfaces.

d. Billets must have gasting numbers

e. When the billet quality is stable the number of control actions can be reduced.

The undersigned has given information about billet defects and how to prevent them to all persons which have interest in the problem. There is nothing to prevent to start quality control in a modest way.

Hama 20-06-1981

Mauri Peltonen

III.CONCLUSION

In this report problems causing low production at Gecosteel have been dealt with. Often the problems are depending on bad castability of steel. The most common reasons causing bad castability of steel at Gecosteel are as follows:

- scrap availability is poor in both quantity and quality
- lime (CaO) is not available
- the steel temperature is often too high
- the analysis of steel is difficult because the spectrometer has been out of use for a long time
- due to the lack of proper quality control correct feedback information from casting and rolling is not possible to obtain
- schooling and training of new personnel is not available in practical level and if available, it is poor.

To improve the situation many recommendations have been made in this report. It should be possible to improve castability of steel with gasstirring, which is widely dealt in this report. Normally we are assuming that gasstirring has got one main task of temperature equalizing but it has also got some other influences. These are as follows:

- equalizing of chemical composition of steel
- quickly melting of alloy elements, deoxidation agents and cooling scrap added in the ladle
- improving of steel cleanness
- reduction of bottom skull in the ladle

Concerning continuous casting many problems are dealt with and the main causes of different casting disturbances are investigated.

Generally it can be said that the main disturbances are due to breakouts. During May and June disturbances due to bad steel quality have increased considerably, but the breakout rate has gone down continuously. The breakout rate in May was 4.9 % wherewas it was 10-15 % earlier.

Mechanical disturbances are not very dominant, but shears have interrupted casting from time to time, sometimes electrical disturbances have also occurred. Due to improper functioning of equipments, some other disturbances have been as result, but these are not brought out in the casting report because these are indirect.

To better know, what is happening in the steelwork, the undersigned has made monthly reports where production, yield and breakout rates + some other problems have been dealt with. These three factors have indicacted a good picture of the situation in the plant. Production has increased from level 2500 tons/month average during the last 2 years to 3550 tons/month durhg the 5 first months of 1981. The best monthly production of 4700 tons was achieved in March 1981.

In spite of problems it should be possible to produce 5000-6000 tons in continuous casting plant each month, if only adequate amount of castable steel is fed to the continuous casting machines. With a minor change and improvement in operation and maintenance the production level can be increased to 7000 tons/month. A normal production of 10 000 - 12 000 tons/month is not possible without going deeply into the problems of preventive maintenance, spare parts availability, schooling of personnel and their aptitud to work and incentive.

Yield from molten steel to good billets has been 90-92 % in the best weeks, but normally 80-90 %. Some improvements have happened, but it is much to do, because normally the yield in similar plants with similar production is about 96 %.

The aspects of maintenance which are directly related to on operation and quality control are mainly dealt with in this report.

Downtime of plant due to maintenance is not the only aspect to be looked upon. There is an important relation between planned maintenance and unplanned maintenance. Unplanned maintenance can sometimes be short and maintenance cost may be low, but cost of production loss will be much higher than maintenance cost.

Because the mould is the most important part of the casting machine, attention is paid to its control and maintenance. Improvements have been made for mould lubrication.

In the area of secondary cooling system many changing and improvements have been made (removing of corner nozzles, more effective cooling ring and nozzle pipes are now welded to the main pipes instead of original screwed joints with gaskets). Product quality aspects have been stressed in different connections in this report and necessary recommendations are given.

The last, but one of the most important thing is to organize an effective schooling system for the personnel.

Betriebsanweisung für Industrieöfen
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Type	SSKDH 390	
Capacity	25 - 30	t
Shell diameter	3900	mm
Electrode diameter	405	mm = 16"
Electrode pitch diameter	1130	mm
Tilting angle for tapping	42	°
Tilting angle for deslagging	15	°
Furnace cover swivelling angle	70	°
Electrode stroke	2350	mm
Stroke of cover lifting device	118	mm
Cover stroke	250	mm
Cover swivelling stroke	468	mm
Total stroke time of cover lifting device	75	sec
Carrying capacity of crane for furnace assembly, min.	32	t
Weight of furnace shell with lining, abt.	60	t
Weight of cover ring with lining, abt.	11	t
Door opening (width x height)	850 x 650	mm
Door stroke	740	mm

Betriebsanweisung für Industrieöfen

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Key to illustrations

1 Furnace shell
2 Furnace brick-lining
3 Tilting cradle
4 Tilting cylinder
5 Cradle stopping
6 Sand seal
7 Guide bolt
8 Cover closing edge
9 Cooling rings
10 Cover carrying arm
11 Electrode carriage guide
12 Electrode carriage
13 Guiding pinion
14 Suspension spindle
15 Cover lifting piston
16 Shim
17 Angle iron
18 Stopping screw (electrode cylinder)
19 Setting screws
20 Nuts for electrode carrying arm
21 Electrode grip
22 Current transition to electrodes
23 Pressing jaw
24 Pin
25 Pressing rod
26 Accumulator
27 Coupling
28 Insulation
29 Bores
30 Laminated springs
31 Hydraulic cylinder
32 Piston
33 Compressed water connection
34 Return screw

- continued -

35 Tilting cylinder bearing
36 Piston rod
37 Guide sleeve
38 Seal
39 Scraper ring
40 Lub nipple
41 Piston seals
42 O-rings at piston rod
43)
44) O-rings at cylinder cover
45 Coupling piece
46 Counter-nut
47 Door lifting cylinder
48 Carrying hook
49 Carrying nipple
50 Cover lifting cylinder
51 Cooling ring holder
52 Cooling ring holder insulation
53 Grooved track of cover lifting piston
54 Guide roll of cover lifting cylinder

- continued -

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BROWN BOVERI

Operation Instruction for
Arc Furnace SSKDH Annex 4

IWT 91503 / D
Blatt 28

BA 22. 111. 031/E
Seite 11

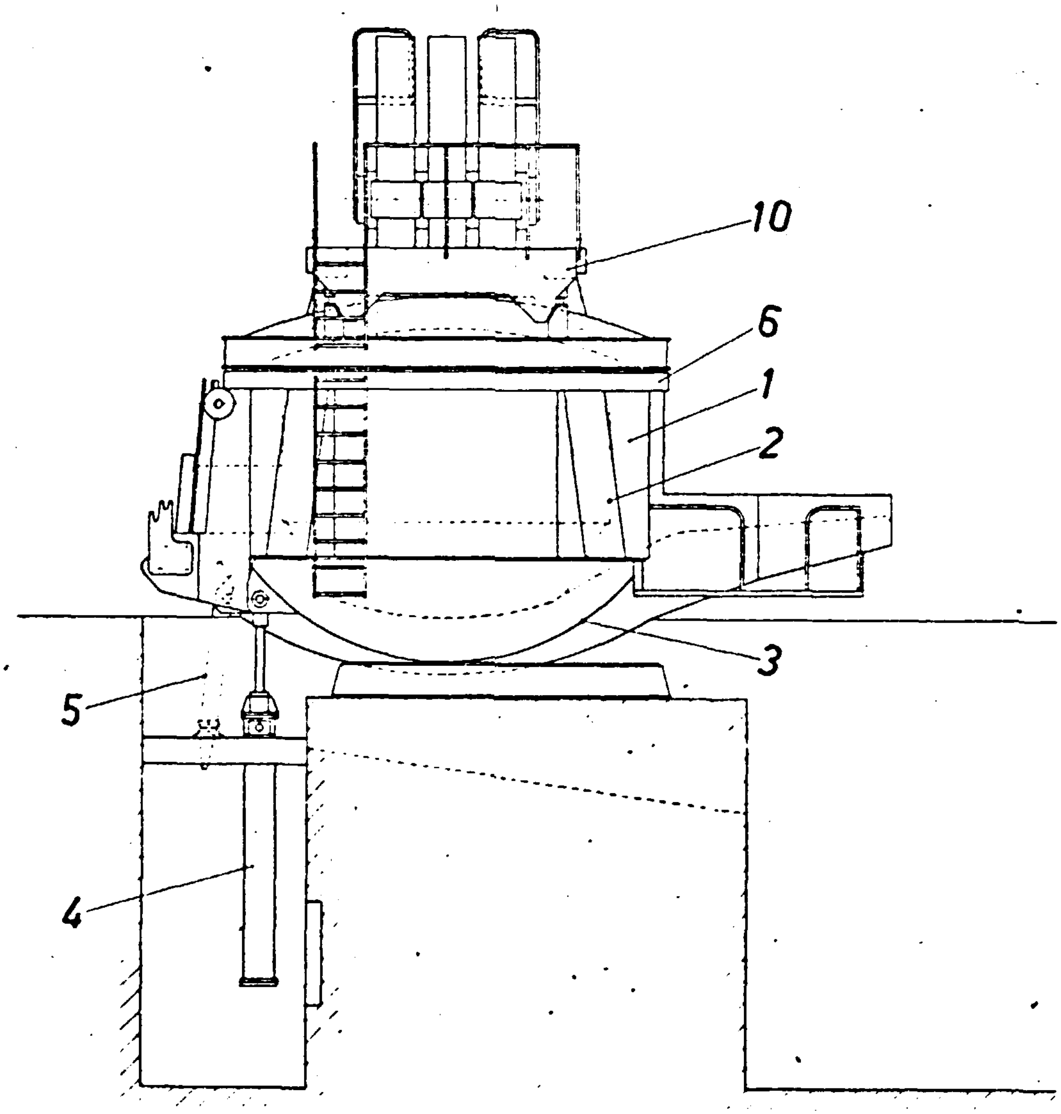

Fig.1

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BROWN BOVERI

Operation Instruction for
Arc Furnace SSKDH
Annex 5

IWT 91503 / D
Blatt 29

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Seite 12

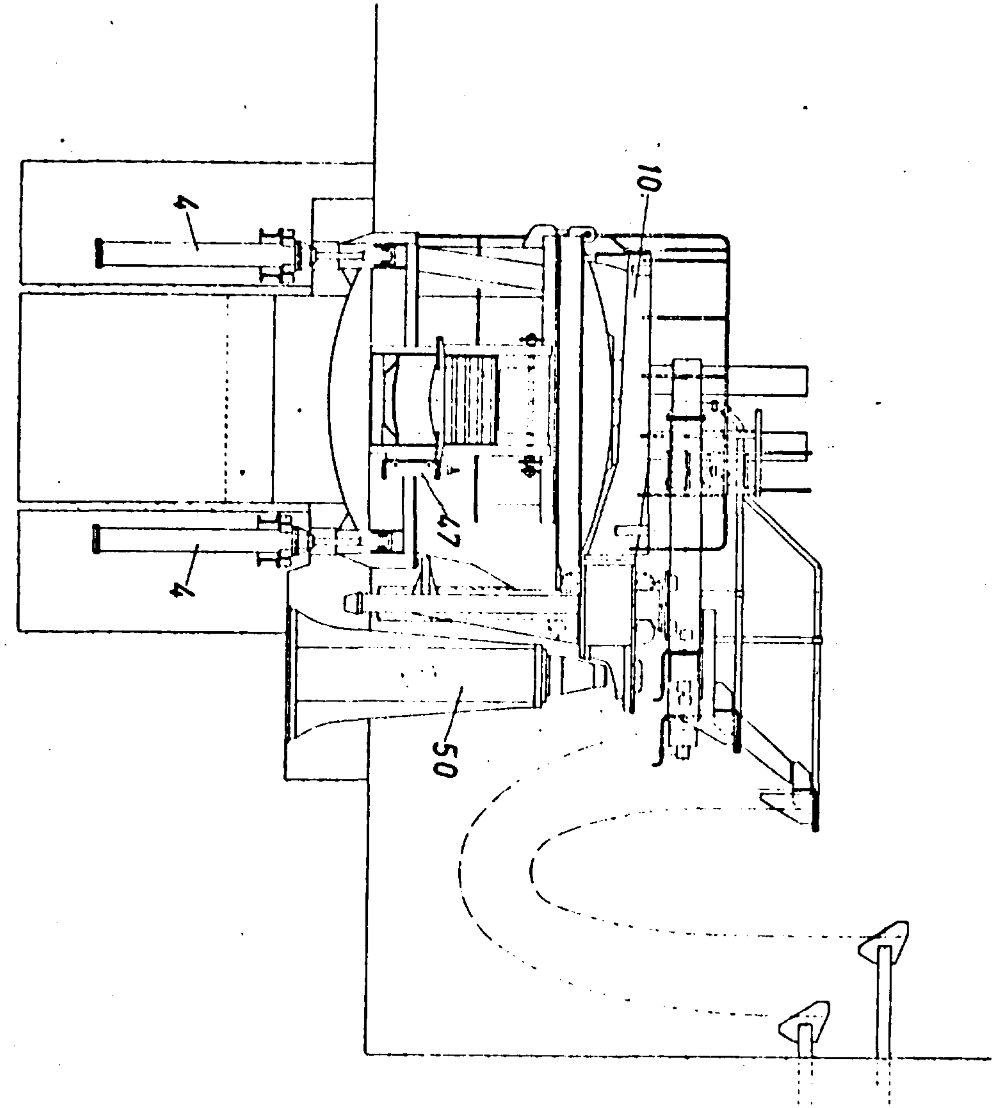

Fig. 2

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Operation Instruction for
Arc Furnace SSKDH

Annex 6

BA 22.111.031/E
Seite 14

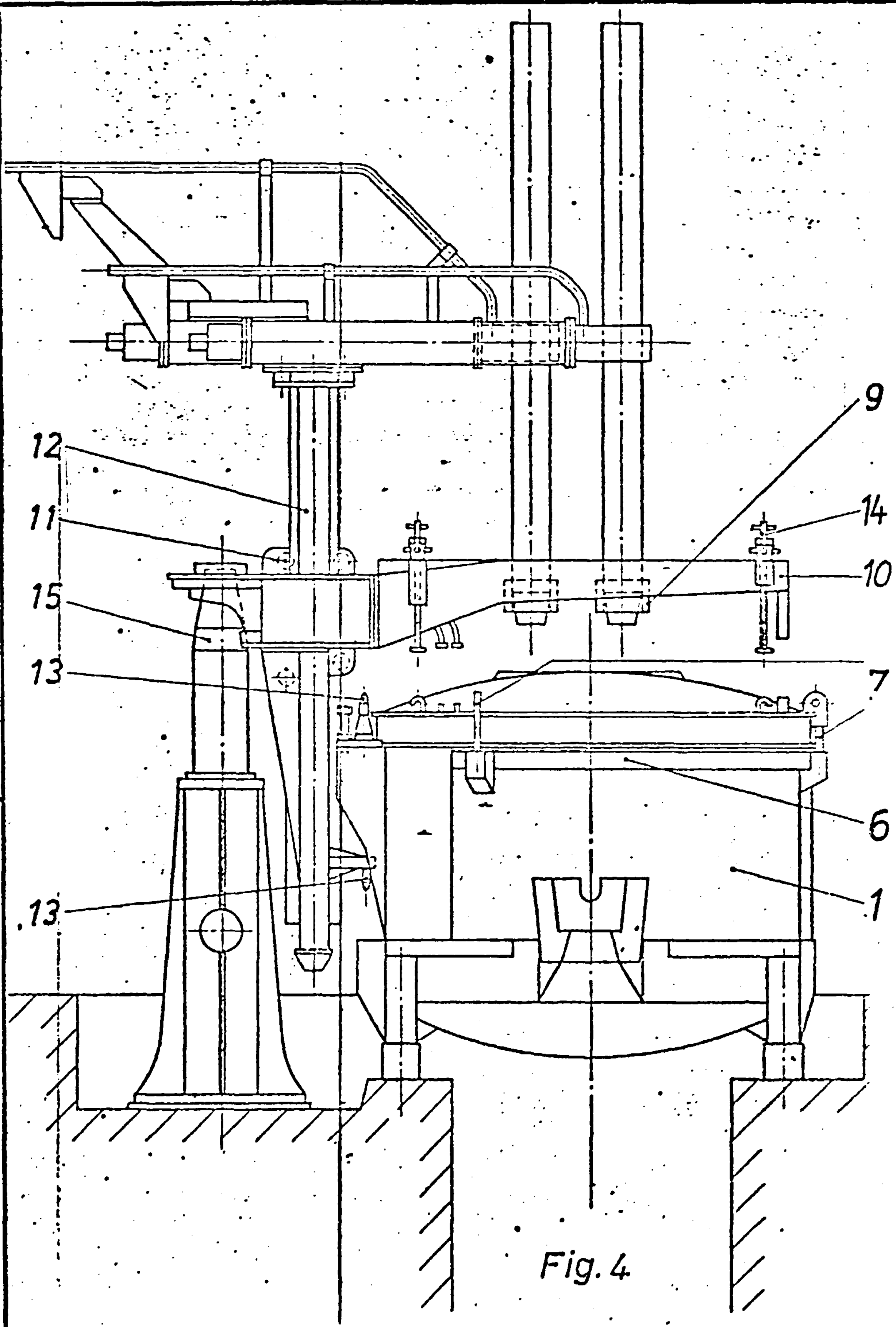

Fig. 4

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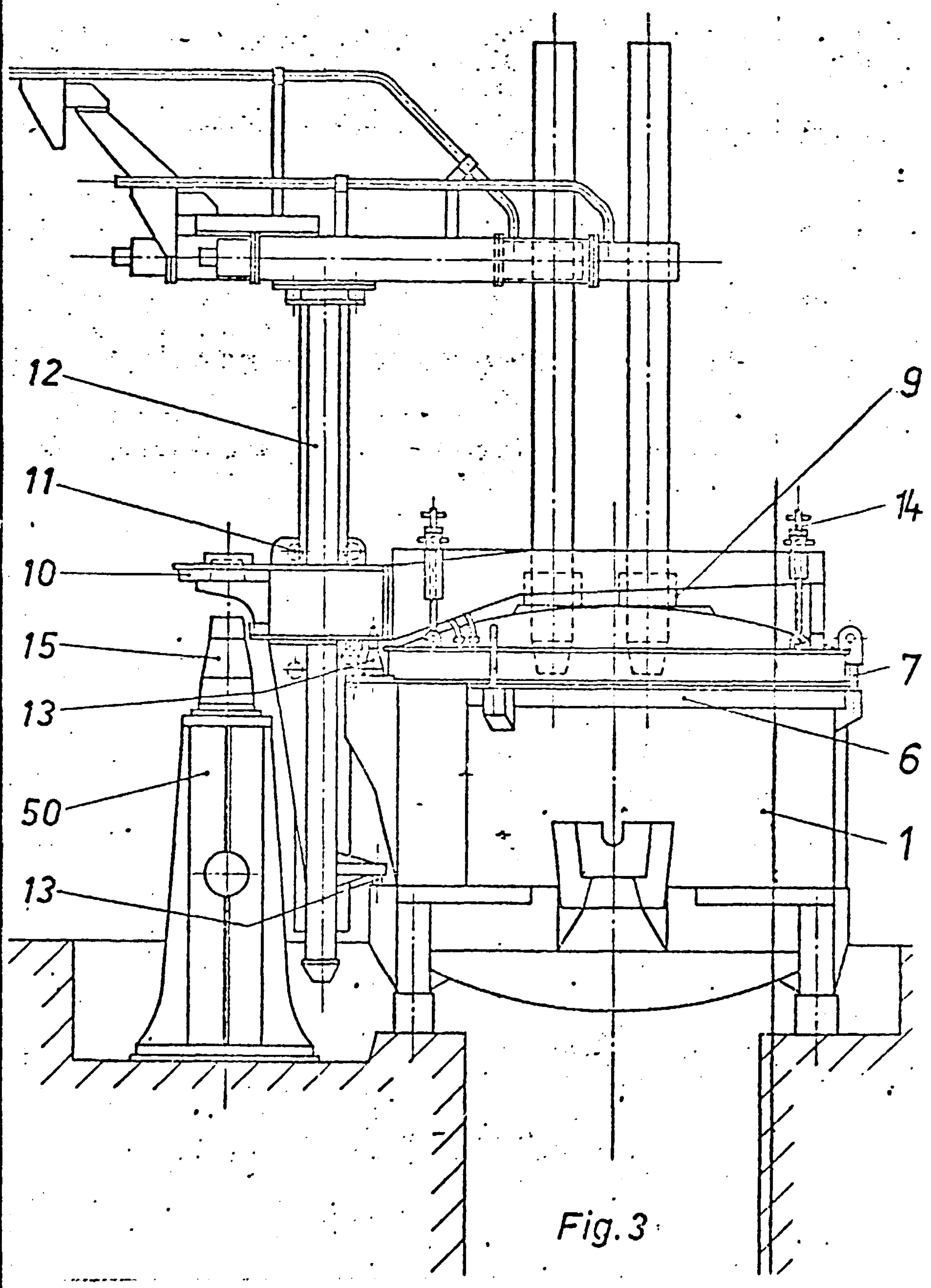

Fig. 3

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SCHLOEMANN-SIEMAG
AKTIENGESELLSCHAFT

General Technical Data

Continuous casting installation	Arc type machine S 13-4
Casting radius	4 m
No. of strands	2 x 2
Strand designation	No. 1 strand on the right as viewed in casting sense
Spacing between strands	900 mm
Size range	80 to 130 mm sq.
Specified unit sizes	80 mm sq., 100 mm sq.
Cutting equipment	Mechanical shear
Shear pressure	230 Mp
Cut lengths	3.0 m and 6.0 m
Machine speed	0.8 - approx. 8.0 m/min.
Casting ladle max.	30 tons valve ladle
Casting platform floor area	2 x 71 m²
Elevation of casting platform above mill floor	4.6 m
Intermediate platform floor area	2 x 40 m²
Elevation of intermediate platform above mill floor	2.2 m
Overall height from cellar to top edge of ladle approx.	12 m
of which above floor approx.	9.5 m
Electric room floor area approx.	36 m²
Hydraulic room floor area approx.	85 m²
Electrical equipment make	BBC, Düsseldorf
Motor list	M - 5605
Voltage	380 V, 50 cycles
Control voltage	220 V, 50 cycles 24 V for solenoid valves

Equipment

Tube Molds

Initial outfit	4 only for 100 sq.
Change parts	4 only for 80 sq.

Strand Guide

Initial outfit	4 only for 100 sq. with additional provision for conversion to 80 sq.

Mechanical Shear

Knife initial outfit	4 only for 100 sq.
Change parts	4 only for 80 sq.

Dummy Bar Chain

Initial outfit	4 dummy bar heads for 100 sq.
Change parts	4 dummy bar heads for 80 sq.

General Arrangement Drawings

Longitudinal section	No. 221 0750
Mill floor ± 0	No. 221 1310
Casting platform + 4 600)	No. 221 0590
Intermediate platform + 2 200)	

Problems with slag by steelmaking and continuous casting

When we are casting small billets with continuous casting machine for normal use (for example concrete reinforcing steel bars), steel generally is deoxidized in ladle with Mn and Si. When the temperature goes down 100°C, (for example between ladle 1640°C and mould 1540°C), soluable oxygen balanced with Mn and Si reduces about to the half.

This extra oxygen can furthermore react with Mn and Si (slag formation) or with carbon (formation of gas bubbles) . What reaction will happen depends on the temperature dependence of oxygen potential, Δ C, and on the carbon content of the steel.

The Mn/Si relation of the steel has a direct influence upon MnO/SiO_2-relation of produced slags, and so upon separating conditions of slag. When the Mn/Si-relation of the steel goes down share of silica in slag increases and also the melting point, surface tension and viscosity of slag too. By relation of 1,5 saturation of silica is achieved. Now solid silica inclusions are produced with optimal separating conditions.

It means: Low Mn/Si and unsuitable temperature praxis produces slags, which are separating in the mould. These slags have a negative influence on the strand surface and breaktout rate. The macro-cleanness will be better because of the above mentioned.

By Mn/Si about 3, we have no bigger problems with separated slags in the mould, but we can not achieve any essential improvements only with an accurate adjustment of Mn/Si relation.

An important precondition to prevent secondary oxidation reactions is, that the temperature difference between deoxidized steel in the ladle and in mould must be so low as possible. This low temperature difference between ladle and mould diminishes many other strand defects for example tension cracks, segregations and central porosity.

Unfavourable relation between charge weight and capacity of casting machine can often result in long casting times and so higher steel temperature in the ladle is necessary. We can improve the situation with cold tundish with good isolations plates, good isolation powder on the steel surface in the ladle and tundish, good ladle isolation and in an emergency situation with oxygen blowing in the tundish.

11-04-81

Mauri Peltonen

Steelmaking in Gecosteel 1981

The steelmaking results in Gecosteel have been very changeable and mostly bad for a long time. By continuous casting about 25-45 % of all strands started are interrupted because of different disturbances. Over 50 % of these disturbances are depending more or less on bad castability of the steel. (Blocking of tundish, nozzles, erosion of tundish nozzles, too much slag in the steel, too high steel temperature or sometimes too low temperature).

With the steelmaking praxis used by Gecosteel it is impossible to get good results always. Too high S-content is very often a problem; When we have low $\frac{Mn}{S}$ (10-15), cutting faces of the billets are very bad (hot short steel). One big problem of the steelmaking is the using of time (too much). Time is not only a productivity factor, but it is very important when we are thinking of results of a metallurgical process in a furnace. With a proper working it should be possible to reduce the total tap to tap time about 50 %. Bad scrap and shortage of scrap has recently been one big problem and the using of $CaCO_3$ (limestone) instead of lime (CaO) is another problem. The following instruction is made according to steelmaking results by Gecosteel and by OVAKO in Finland. The undersigned has carried on correspondance with H. Peltola (chief of the melting shop in Imatra Steelworks in Finland) concerning desulphurization and deoxidation of steel.

A. Short theory of dephosphorization, desulphurization and removal of H and N.

1. Dephosphorization

- low T ($\leq 1600^{\circ}C$)
- basic slag $\frac{CaO}{SiO_2} > 2.5 \ldots 3.5$
- oxidizing conditions in the furnace

By making of low carbon steels dephosphorization normally is no problem, but by using correct desulphurization method P-content can increase because of negligent deslagging.

2. Desulphurization

- high T (1600 - 1700°C)
- basic slag
- deoxidizing conditions in the furnace

Desulphurization and dephosphorization will be intensified by effective reaction between slag and steel-effective mixing.

3. Removing of H and N

- effective oxygen blowing into the steel.

B. Instruction of steelmaking

1. Carbon must be put into the furnace so early as possible, for example before the first scrap basket. Carbon must be added so much that Δ C (amount of C which is possible to blow down with oxygen) 0,2 - 0,5 % is ensured. In case of Gecosteel about 200 kg coke is recommended. It is not impossible to add C before the second scrap basket.

2. Limestone must be added in an early stage too. Main part of limestone can be fed during first basket and all limestone before scrap is completely melted. The present amount abt 1000 kg/charge is not always sufficient. The right amount would be abt 1500-2000 kg. By using lime (CaO) $\leq$ 1000 kg is OK.

3. In a latter stage of melting operation ($\sim$10 min before melting down) it is possible to start oxygen blowing into the furnace with a low pressure and low flow rate ca 2.5 m^3/min.

- careful deslaggning (with tilting) which must be continued during the whole oxygen blowing

- with these measures it is possible to get a good dephosphorization.

- temperature can be taken in this stage quite high (1600°C).

4. Effective oxygen blowing with flow rate ~ 8 m^3/min. Min C must be 0,2 - 0,3 % the total oxygen amount will be ≤ 100 m^3. After the oxygen blowing rest slag must be removed with this accuracy, which is possible in prevailing conditions. T ~ 1630 - 1660°C.

5. Primary deoxidation with Al. The right amount of Al must be fixed with trial, but it is possible to start for example with Al = 10 kg and then add during the following test charges Al amount 2 kg steps until blocking limit is reached. Alloying of Mn is recommended at this stage, preferably with SiMn but FeMn is OK too.

6. By using limestone it is not allowed to add more limestone in this stage, but we now must make reduction of the rest of the slag in the furnace with about 50 kg CaSi + 20 - 30 kg carbon powder + a temperature increase of 10 - 15 min.

The amount of reduction agents are big, but it is recommended because sometimes working can be negligent and more as 10 - 15 min time is needed.

If it is possible to use CaO it will be added at this tage 200 - 300 kg + Ca $_2$ abt 20 - 30 kg and after the slag melting reduction of slag like above.

7. During tapping we probably don't need to add any Al, but if necessary only 2-5 kg into the ladle.

- CaSi during tapping 30 - 50 kg into the ladle. If all Mn is not alloyed earlier into the furnace, this must be added now into the ladle.

It should be useful to make about 5 charges according to these instructions and then an evaluation of the results. After the evaluation it is perhaps necessary to make some changes of the method. Evaluation criterion must be a bood castability and billet quality but not minimizing the work.

02-06-81

Mauri Peltonen

Annex 12

Reports which Mauri Peltonen has written during his stay at Gecosteel 1980-81.

1. Possibilities to improve production of continuous casting plant by Gecosteel. 1980-12-04

2. Action which can reduce essential the present high breakout rate in continuous casting plant in Gecosteel. 1980-12-13.

3. Erosion of tundish nozzles in Gecosteel 1980-12-19.

4. Oils for mould lubrication. 1981-02-25

5. Importance of steel temperature for succesful continuous casting. 1981-02-28.

6. Some points which must be repaired during production stop (6-8)03-81 in continuous casting plant. 1981-03-04

7. Influence of tundish nozzle upon the casting results. 1981-03-07

8. Using of asbestos plug by starting of casting. 1981-03-11

9. Statistics concerning production in February 1981. 1981-03-17.

10. History of charge Nr 230 from furnace 2. 1981-03-31

11. History of charge nr 237 from furnace 2. 1981-04-01

12. History of charge nr 242 (B242). 1981-04-04

13. History of charge 2-245. A 316. 1981-04-04

14. History of charge 1-229, A 312. 1981-04-04

15. History of charge 234-4 by machine 13. 1981-04-05

16. Statistics concerning production in March 1981 in Gecosteel. 1981-04-08.

17. Problems with slag by steelmaking and continuous casting. 1981-04-11

18. History of charge 263-1, B 297. 1981-05-04

19. Statistics concerning production in April 1981 at Gecosteel. 1981-05-05

20. Importance of mould cooling for continuous casting. 1981-05-10

21. History of charge 440 A 338-1. 1981-05-12

22. History of charge 338-1. 1981-05-16

23. Visit to continuous casting machine at Torras Herreria y Construcciones S A in Castell Bisbal (Barcelona) Spain. 1981-05-19

24. History of charge 374-1. 1981-05-24

25. Steelmaking by Gecosteel. 1981-06-02

26. Statistics concerning production in May 1981 at Gecosteel. 1981-06-06

27. Investigation of steel temperature in ladle and tundish by Gecosteel. 1981-06-07.

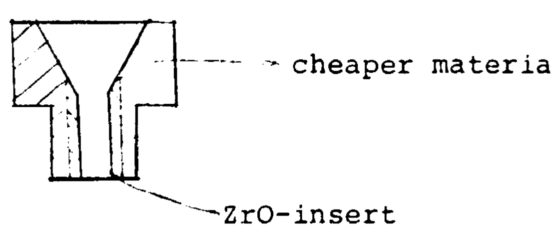
Erosion of tundish nozzles by Gecosteel

It has been problems in continuous casting plant many times recently because of heavy erosion of tundish nozzles. Erosion has sometimes been so big that it has been necessary to lower the steel level in the tundish so,that the slag can easier escape from the tundish through nozzles into the mould. Otherwise this kinf of lowering increase the amount of slag in the mould, because the steel level in the tundish must be more than 250 mm during casting. Visibility to tundish at the moment is poor particularly when the steel level in the tundish is low. The situation will be better when a new tundish cover has been taken in use.

Erosion of tundish nozzles can depend on the following factors:

1. Poor quality of the tundish nozzles

Actual tundish nozzles Ø 13 and Ø 14 from Didier and Marchal are good enough for ~ 2 hours casting if the steel is good deoxidized and the steel temperature is normal. But unfortunately the situation is often exceptional (too high steel temperature, poor deoxidization or it is necessary to open nozzles with ozygen). If we use ZrO (< 96 %) nozzles we can prevent this kind of problems, but the high quality nozzles are more expensive. A cheaper and often good solution is to use nozzles with high ZrO insert.



Insert withstands very well normal erosion during casting and casting times of 4-5 hours are possible, but insert will be damaged easier by oxygen blowing than normal ZrO nozzle. The undersigned can check the prices of different types of nozzle solutions.

2. Steel temperature too high

It has been a big problem by Gecosteel but recently the situation has been a little improved. Now according to instructions max ladle temperature is 1660^{o}C and min can be about 1610-1620, but when the temperature measuring in the tundish is possible we must check it more accurately.

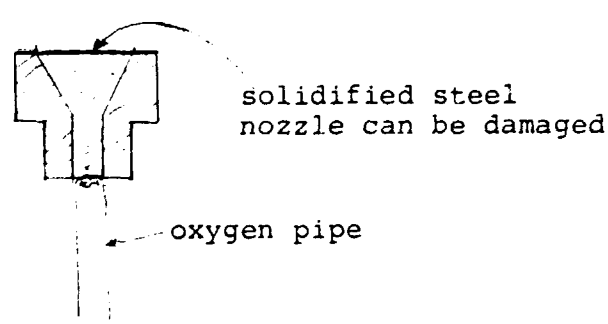
3. Low carbon steel with high Mn-content (Mn > .80) is very corrosive, but this is no problem at Gecosteel because the Mn-content is ~ .40 - .50 %.

4. Bad steel deoxidization

This is a common phenomen by Gecosteel, but deoxidization is very seldom so bad that the steel is boiling in the mould. Boiling steel is impossible or very difficult to cast. We can improve the situation a little if we add CaSi and possible Al-wire in the tundish during casting. In case of bad oxidized, but no boiling steel casting is going very well with high ZrO nozzles.

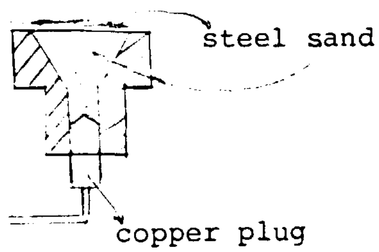
5. Starting of casting with open nozzles

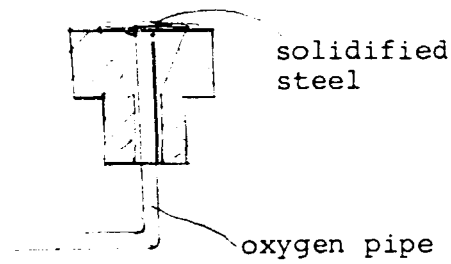
It happens sometimes that first it comes steel from the tundish, but after a few seconds steel is solidified in the tundish nozzles and it is necessary to open nozzle with oxygen. Now nozzle is full of steel and during burning the nozzle can be damaged.



Aforementioned can happen very easy if we have problems to open sliding gate nozzle.

If we put sand and copper plug into nozzle before starting, we must often use oxygen for opening too, but the nozzle will not be damaged so easy.





in this case nozzle will not be damaged

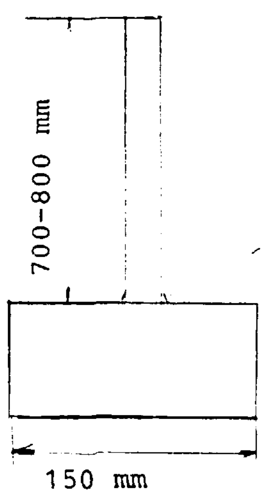
1980-12-19

Mauri Peltonen

History of charge 440 A 338-1

The starting has gone good, but the casting speed of strand 2 was lower than for strand one (tundish nozzles have been opened without oxygen). Because of a low casting speed and little uneven cooling in the secondary cooling zone the strand was bent to the other side and the casting was to be stopped with strand 2.

With a big hammer (10 kg) it is very easy to slap the strand to the center of the roller path. The problem is that there are no big hammer available. My proposal is to make 3-4 hammers itself by Gecosteel according to the following sketch.



pipe Ø 30-40 mm

welding

Piece of billet ⊄ 100 mm
Steel quality St 37

It should be mentioned that the billet and the pipe are own products of Gecosteel.

1981-05-12

Mauri Peltonen

Investigation of steel temperature in ladle and tundish by Gecosteel

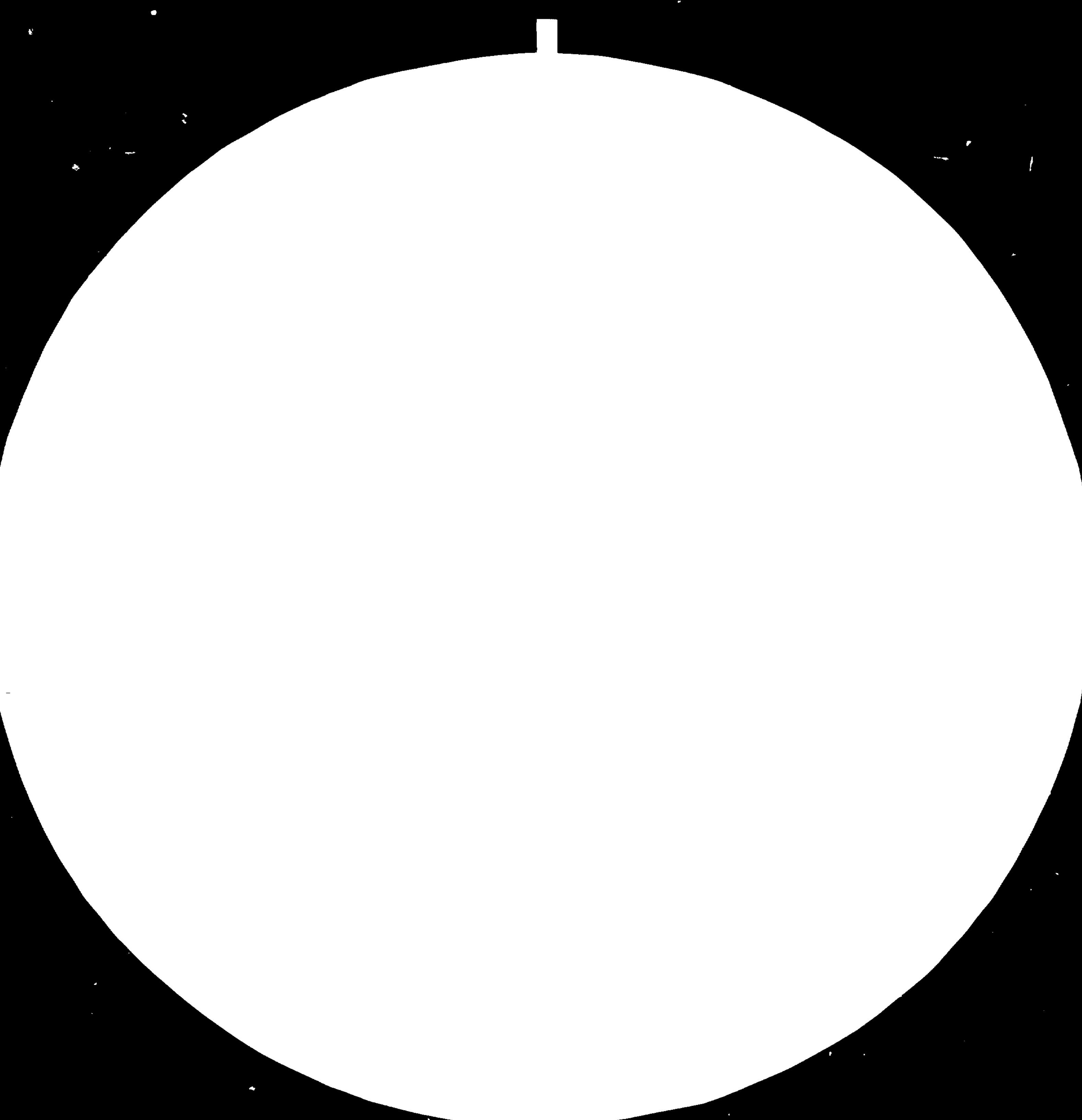
Earlier the steel temperature in the tundish could not be taken in the measuring system due to defect. This started functioning in March 1981. Measurement has mostly been taken in casting machine no 1. A form was made for recording the temperature in the tundish with other datas (annexes 1-3). The preheating temperature of the ladle was evaluated visually, as no temperature measurement is feasible with instrument.

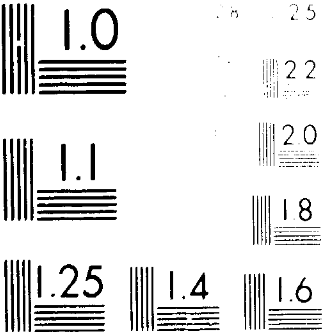
Nine heats were analysed, seven with two strand casting and two with one strand casting. In annexes 4-5 investigation results are indicated for a similar plant (Imatra Finland). Ladle capacity of the above plant is 40 ton (18 MVA), tap to tap time 2-2½ h producing steel for merchant mill. The casting machine is 3-strand Concast S-machine and the billet size ⌀ 100 mm.

The tap to tap time being good the circulation time of the ladle was short, as a result of which the ladle lining temperature was consistent and warm. The temperature drop between the ladle and the start of the tundish is in average ca 75°C with 3-strand casting. With 2-strand the average is ca 95°C.

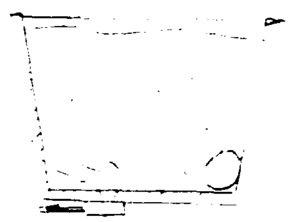
During casting the temperatur drop in the tundish is about 20°C in both cases. Similar datas are shown in annex 5 for Gecosteel. The temperature drop between the ladle and the start of the tundish is 80°C for 2-strand casting and 90-95°C for 1-strand casting. The temperature drop in the tundish is 50-55°C in average in case of 2-strand casting and 30°C for 1-strand casting. The ladle lining temperature was high in case of 1-strand operation hence the drop is lower compared to that of 2-strand casting. An investigation was made 10 years ago at Imatra with stopper rod in the ladle. But after introduction of sliding gate in the ladle, the temperature drop occured quickly at the end of the cast, when 2-5 tons steel were remaining in the ladle.

82.06.24



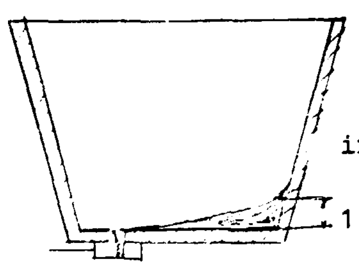

2.5
2.2
2.0
1.8
1.0
1.1
1.25
1.4
1.6

The cause of rapid drop of the temperature was investigated and it was found that a cold steel pocket was formed at the opposite corner of sliding gate (see sketch) due to slow and constant steel flow through the sliding gate. When 2-5 tons of steel were remaining in the ladle the pocket came out causing rapid temperature drop in the tundish.



By making the stopper open ca 20 seconds and closing ca 40 seconds, the steel flow rate would be increased preventing formation of cold pocket.

A solution of this problem was to use inclined ladle bottom (see sketch).



In many cases similar rapid drop of temperature in the tundish at the end of the casting has occurred in Gecosteel (sliding gates is used).

Recommendations

1. Effective preheating of the ladle, so that the temperature of lining of all ladles are more or less the same.

2. Short ladle ciculation time as far as possible.

3. Implementation if gasstirring in the ladle as soon as possible.

4. Inclined bottom lining in the ladle should be tried.

5. It is very important to take 2-3 measurements of the temperature in the tundish. If the temperature goes down rapidly, more measurements are to be taken. In case of a low temperature ($T^{o}C < 1530$), CaSi and O_2 blowing could be used. It is not recommended to blow O_2 too early, because the tundish nozzle erossion increases.

1981-06-07

Mauri Peltonen

Annex 1

Temperature measurements in continuous casting plant by Gecosteel

Date 31-05-81 Shift ______

Arc Furnace No 2 Charge No 392 CC Machine No B Cast No 334

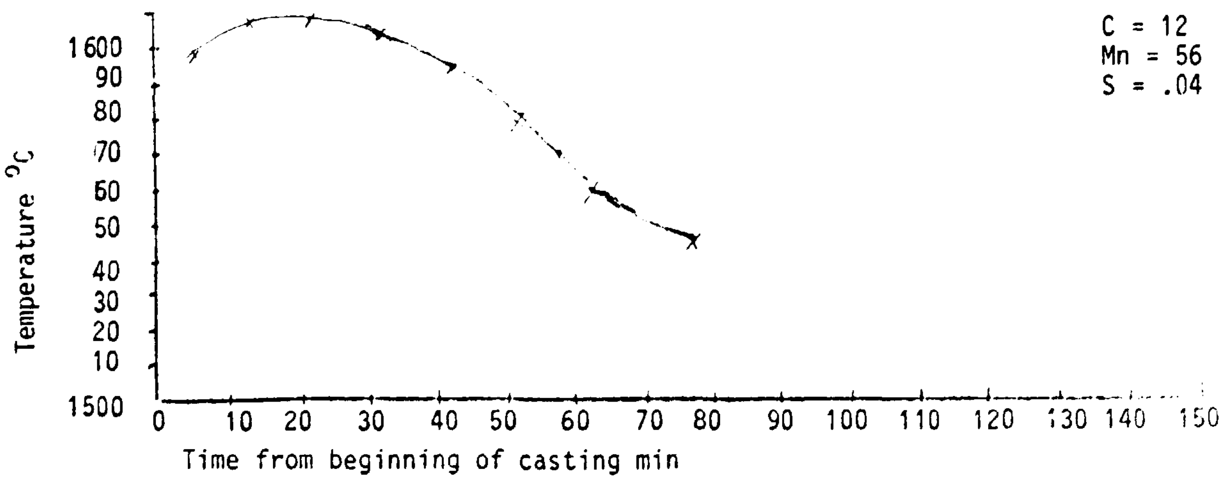
Ladle No ____ Ladle lining life ___ Preheating temperature of ladle °C 550 Preheating of ladle terminated at 7.00

Beginning of tapping at 7.18 Tapping time min 3.5 Furnace temp. °C ______

Ladle temperature in melting shop °C _______ Ladle temperature in cc-plant °C 1700 Starting of casting at 7.35

Tundish Temperatures

Time from beginning of casting min	Tundish temperature °C	Casting speed strand 1	strand 2	Steel level in tundish cm below max level	Remarks
5	1600	3.3	3.5	5	
15	1605	3.5	3.6	5	
25	1605	3.5	3.5	5	
35	1600	3.6	3.6	5	
45	1590	3.6	3.6	5	
55	1575	3.7	3.7	5	
65	1555	3.7	3.7	5	
80	1545	3.7	3.7	5	Ladle empty but
85					tundish full of
95					steel because of blocking of tun-
105					dish nozzles
115					Cutting faces of
125					billets were bad
135					



C = 12
Mn = 56
S = .04

Annex 2

Temperature measurements in continuous casting plant by Gecosteel

Date 11.5.-81 Snift ______

Arc Furnace No 1 Charge No 321 CC Machine No A Cast No 434

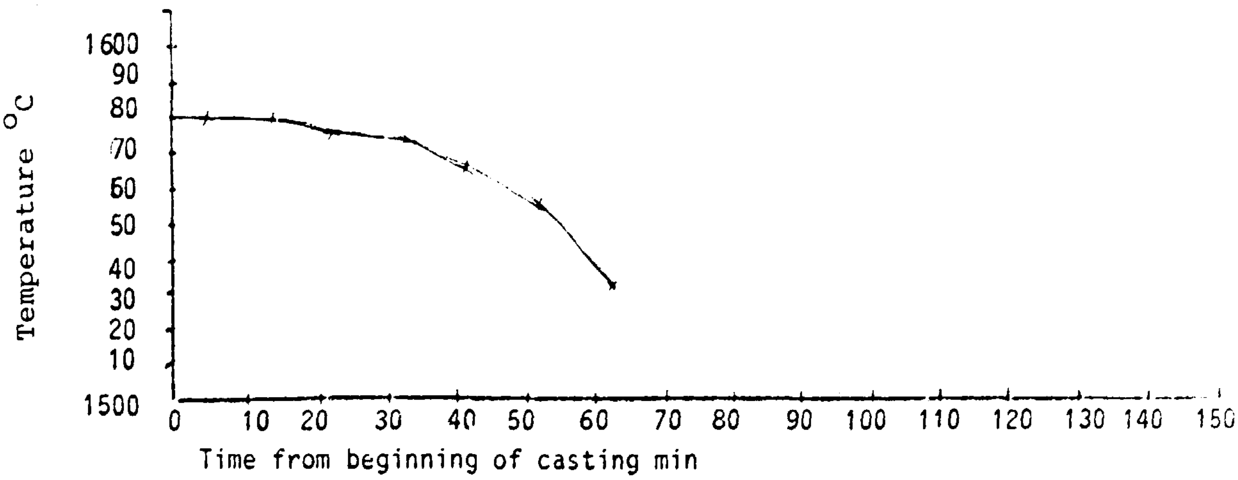
Ladle No ____ Ladle lining life ____ Preheating temperature of ladle °C 650 Preheating of ladle terminated at 9.42

Beginning of tapping at 9.57 Tapping time min 3 Furnace temp. °C 1710

Ladle temperature in melting shop °C ________ Ladle temperature in cc-plant °C 1650 Starting of casting at 10.08

Tundish Temperatures

Time from beginning of casting min	Tundish temperature °C	Casting speed strand 1	strand 2	Steel level in tundish cm below max level	Remarks
5	1580	2.5	2.5	5	
15	1580	2.6	2.6	5	
25	1575	2.5	2.5	5	
35	1570	2.6	2.6	5	
45	1560	2.6	2.6	5	
55	1550	2.8	2.7	5	
65	1530	2.8	2.8	5	Casting time 74 min
80					
85					
95					
105					
115					
125					
135					



Temperature measurements in continuous casting plant by Gecosteel

Date 6.4.81 Shift ______

Arc Furnace No 2 Charge No 251 CC Machine No A Cast No 324

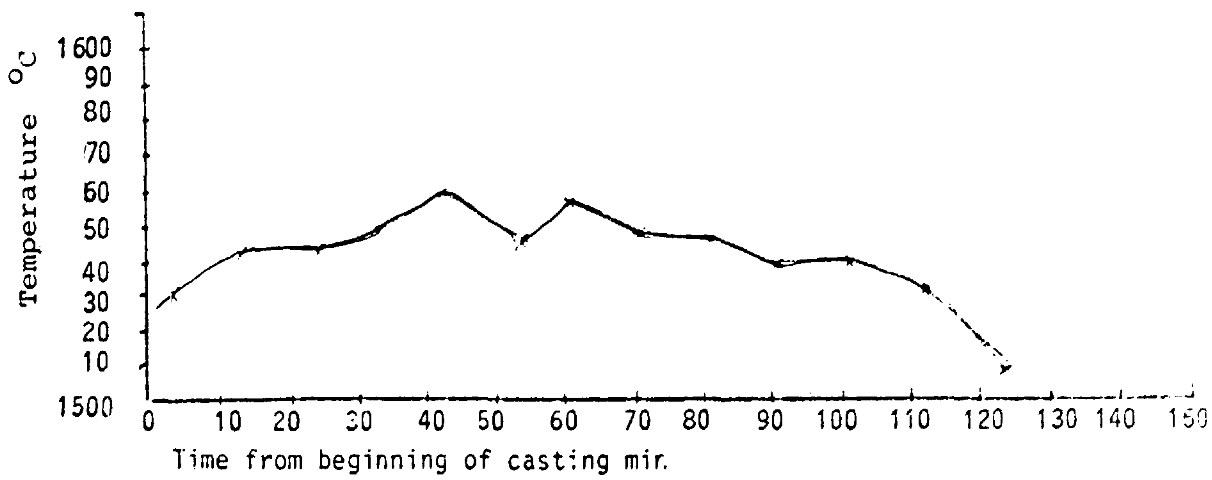
Ladle No ____ Ladle lining life ___ Preheating temperature of ladle °C 800 Preheating of ladle terminated at 8.26

Beginning of tapping at 8.35 Tapping time min 3 Furnace temp. °C ______

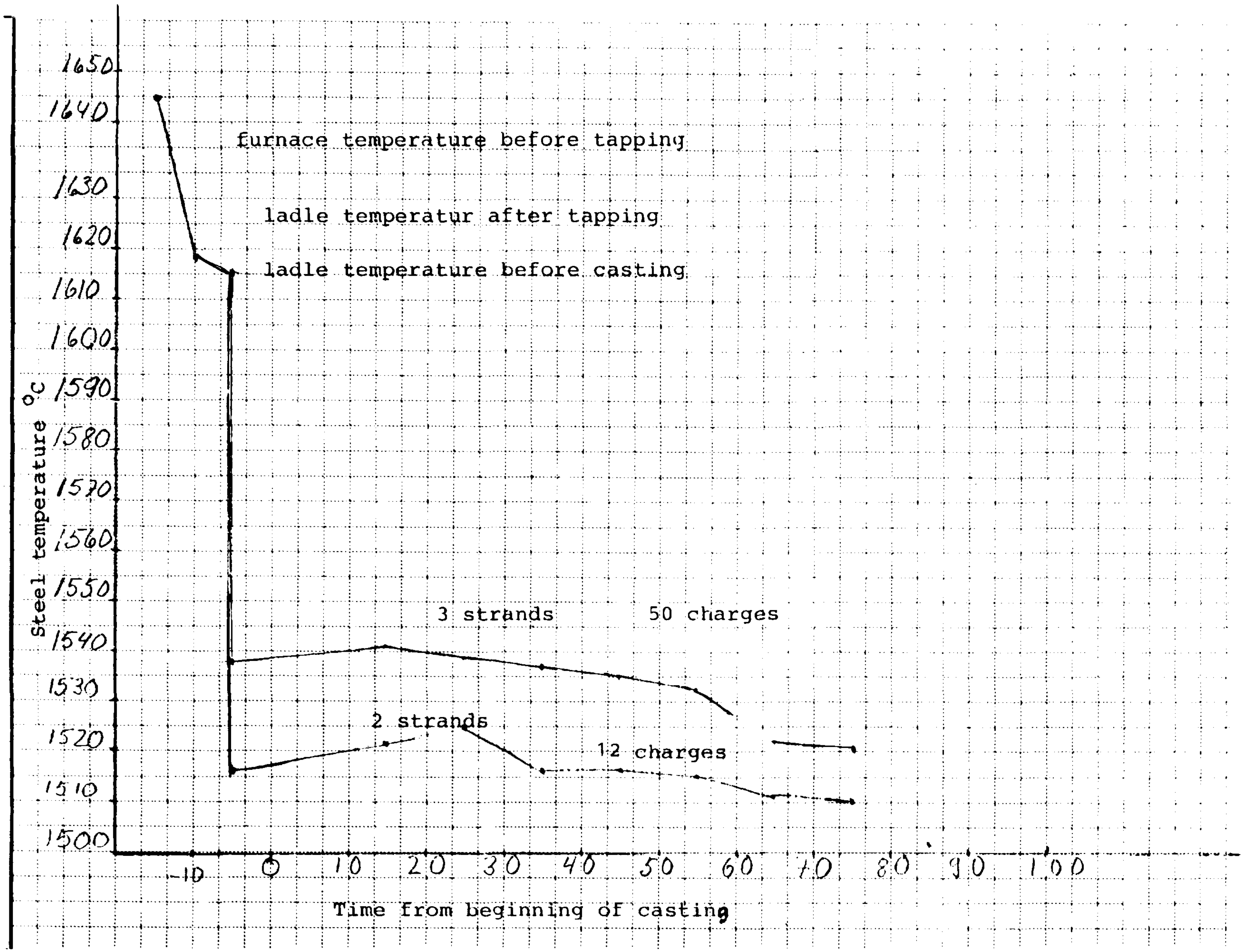
Ladle temperature in melting shop °C ________ Ladle temperature in cc-plant °C 1650 Starting of casting at 8.45

Tundish Temperatures

Time from beginning of casting min	Tundish temperature °C	Casting speed strand 1	strand 2	Steel level in tundish cm below max level	Remarks
5	1530	Breakout by starting	2.4	15	
15	1540		2.95	5	
25	1540		2.95	0	
35	1545		2.9	0	
45	1555		2.8	10	
55	1530		2.6	20	
65	1545		3.02	0	
75	1540		3.06	0	
85	1540		3.16	0	
95	1530		3.06	5	
105	1530		3.16	0	
115	1525		3.12	0	Casting time 123 min
125	1510		3.12	0	
135					

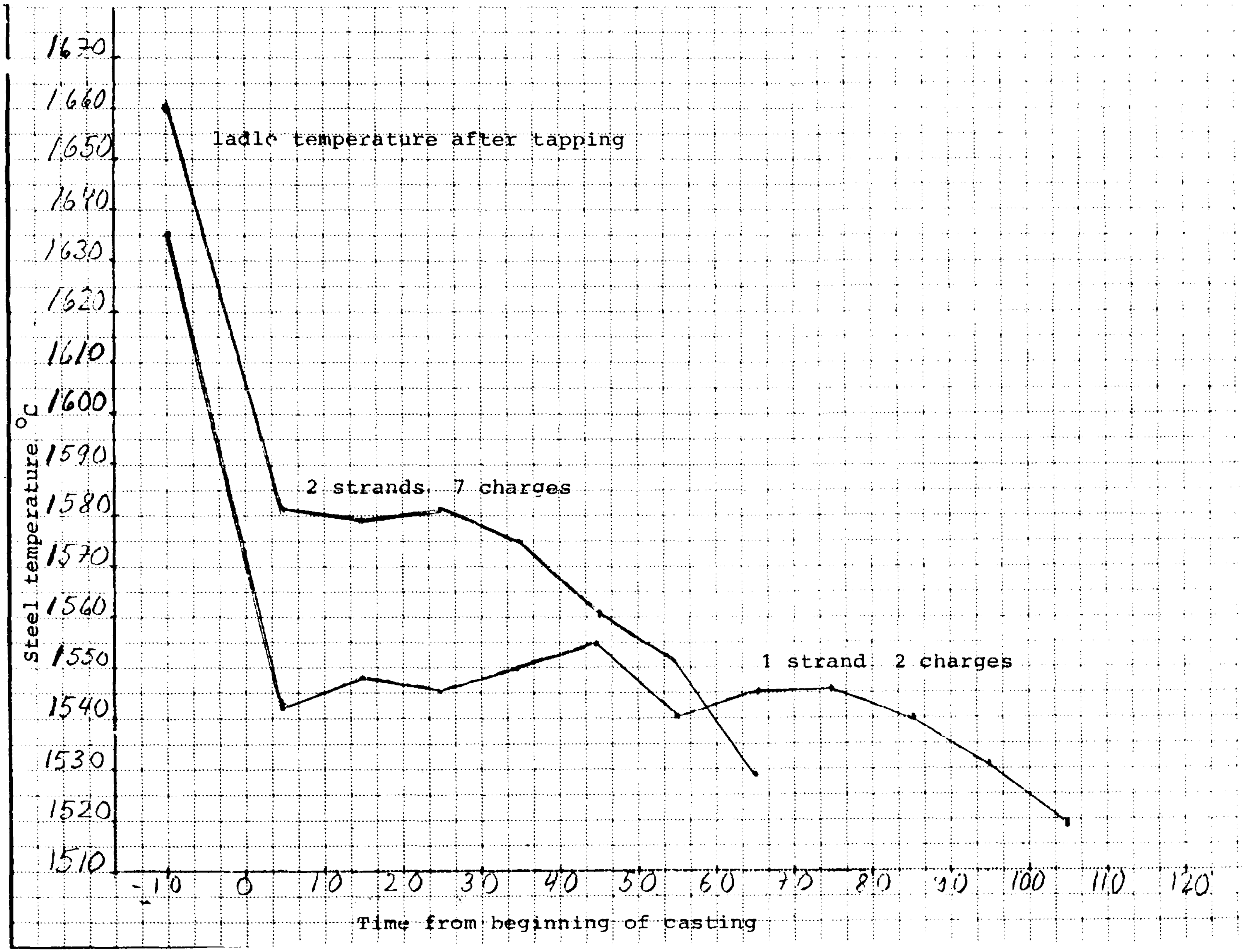


Annex 4



SKF Steel 143 600x50 11.80

Annex 5

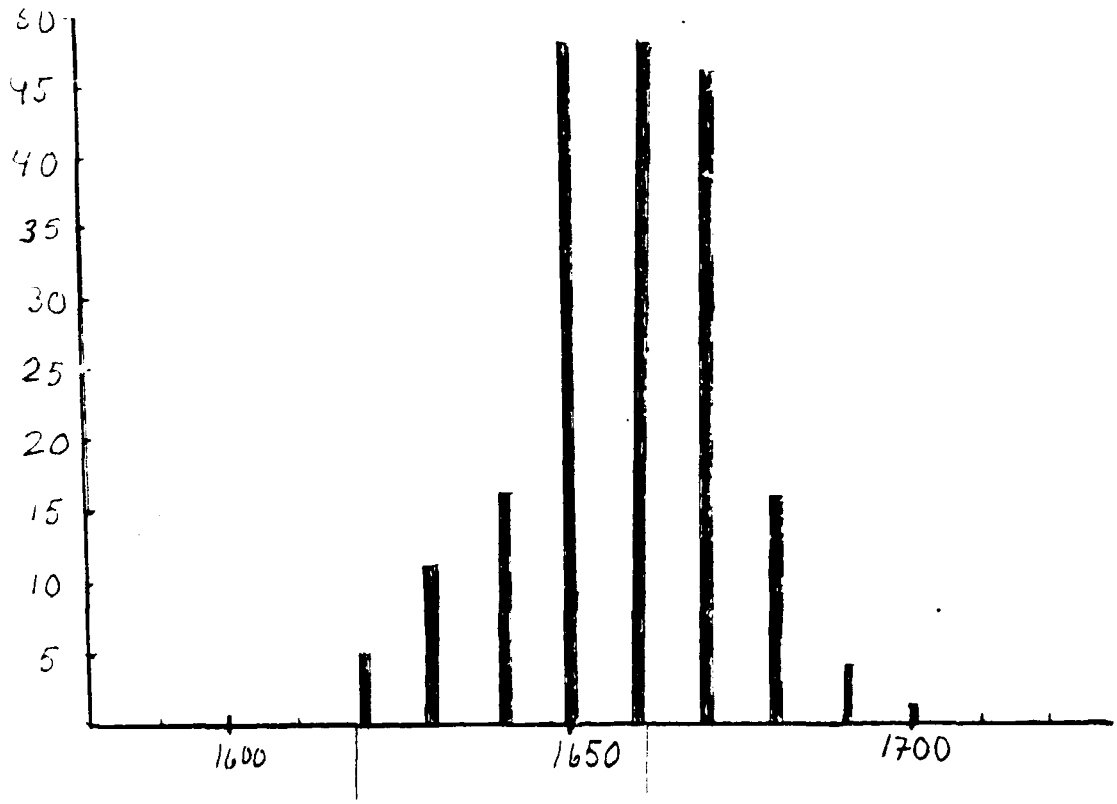


SKF Steel 143. 600x50 11. 80.

Statistics concerning production in March 1981 by Gecosteel

1. Ladle temperature

From the following graph we can see the deviation of ladle temperatures during March.



suitable temperature range

Only 65 % of the temperatures have been in suitable area. It should be mentioned that in February 72 % and in January 62 % of the temperatures were in suitable area. During the last week the situation with the temperatures have deteriorated again. It must be possible to get ca 90 % of the temperatures in this area. In respective report of February we have noted, that with small cooling scrap it should be possible to improve the situation considerable, but the big transportation problem to get scrap to the casting platform from the rolling mill is not yet solved, but many proposals have been made without success.

2. Breakout rate

By means of breakout rate we can very well judge the operation level of a continuous casting plant. In recent times many actions have been made to improve the situation, which have been very bleak, some success has been achieved. On attachment 1 we can see, that the breakout rate has been over 10 % for a longer time which is a very bad value. In March the breakout rate was 7,9 %. This is naturally better but not yet satisfactory. The main causes of breakouts have recently been:

- too high steel temperature
- bad steel deoxidation
- by starting tundish nozzle has burnt too big because of starting with open nozzle
- human error
- dummy bar head has disconnected from strand

This kind of problems we can reduce with steel bars (Ø 15-20 mm, length ca 20-25 cm), which are put around the anchorbolt into the mould before casting. For one mould we need 3-4 pieces, but this kind of bars are not available because of big transportation problems between continuous casting plant and the rolling mill. It should be mentioned that for one charge we need ca 2-3 kg scrap. More about preventing of breakouts in another report.

3. Yield from molten steel to good billets

Yield tells very much about operation level of continuous casting too. On attachment 2 we can see weekly yield in this year. Certain improvement has happened and without this improvement a new monthly production record should not have been possible. In March yield was 90,8 %, which is not very good, but better than in any other previous month. Normal yield in similar plants with similar production is ca 96 % so we have still much to do in this area, but the most pleasant thing is that yield is going upwards.

4. Production

In March Gecosteel has reached a new production record 4 707 802 tons, which is over 500 tons more than over the previous 2 years old record. In the beginning of this month production has been on the same level as in March, so it is possible to make a new record,if something unexpected is not happning. A new record is not coming without hard working and it is necessary to maintain these improvements, which have been made and it is necessary to make many new improvements.

Casting disturbances

We can now say the same things as in previous reports, statistics concerning casting disturbances is not quite reliable because of negligent filling of casting reports, but improvements is still happening in this area. It should be mentioned that 430 strands are included in this examination.

Name of disturbances	Number of disturbances	% of all strands	Remarks
Breakouts	34	7.9	Improvement 50% compared with February, but 7.9 % is still high
Bad steel deoxidation boiling in mould	20	4.7	Instead of blocking tundish nozzles in February there are now many charges with poor deoxidation
Overflow	8	1.9	Caused by bad mould lubrication, mechanical machine problems and human errors, situation is improved considerable during last weeks (6.7 % in Febr)
It was not possible to open tundish nozzle	6	1.4	Slag in nozzle,starting with open nozzles. Share of these problems is increased from 0.8% in Febr.
Problems with shears	5	1.16	Same amount problems as in February
Bad mould lubrication	5	1.16	Casting stopped without other problems (breakout, overflow).No improvements.
Blocking of tundish nozzles	5	1.16	Share of this problem is decreased considerable but deviation of deoxidation results are still very high
Sliding gate nozzle	4	0.93	Situation improved but disturbance level still high
Tundish nozzle too big	4	0.93	Big tundish nozzle causes often breakout,and therefore most of this problems are in the breakout column
Much slag in steel	3	0.7	Slag in steel often causes breakout

Name of disturbances	Number of disturbances	% if all strands	Remarks
Inclined tundish stream	3	0.7	Inclined stream has caused many other disturbances,but in these cases casting has been impossible
Bolt of dummy bar head came loose	3	0.7	These problems we have had more,but they are in breakout column.We can improve the situation by using cooling scrap in mould before starting
Bad secondary cooling	3	0.7	Bad secondary cooling causes many other problems,but in these cases casting has been stopped before it happened something else. The situation is improving.
$\frac{Mn}{S}$ = 8.3 too low	2	0.5	Problems with bad cutting faces and transversal cracks
Circulation of secondary cooling water stopped	2	0.5	Not very common problem
Problems with casting crane	2	0.5	
Launder below tundish were wet	2	0.5	Launders are often wet,but in these cases casting has been stopped because of wet launder
No oxygen pipes available on casting platform	2	0.5	This kind of negligence is almost inexcusable
Steel temp.too low	1	0.25	Very unusual problem
Temp.of mould cooling water too high	1	0.25	1 valve of cooling water for heatexchanger was not properly open
Straightening machine	1	0.25	
Total number of disturbances	118	27.4 %	Considerable improvement compared to February (51%)

We can see that the situation has improved considerably compared to February, but we can not be satisfied before we have reached 10-15 % disturbance level. (10% with 2-strand machine is not a very good value).

This level is difficult to achieve only with continuous casting improvements, but it is necessary to improve deoxidation praxis and temperature control by steelmaking. The most continuous casting problems are caused by negligent control of important functions before casting. Breakout rate was now 7.9 % and during the following months we must reduce this down to ca 5 %, which is not good., but acceptable in prevailing conditions. Normal value by billet casting at similar plants are 0.5 - 2 %. More about other disturbances in separate reports.

1981-04-08

Mauri Peltonen

2. Casting disturbances in May 1981

This statistics is made according to casting reports and notes made by the undersigned. (386 strands were started in May).

Name of disturbance	Number of disturbances	% of all strands	Remarks
Breakouts	19	4.9	Lowest number until now in the beginning of the campaign against breakouts was our target below 5% from value 10-15%
Blocking of tundish nozzles	16	4.1	Share of this problem is now very high only in Febr. the situation was worse. Blocking is caused by high Al-oxide content in steel. In some cases low steel temperature increases incidence of blocking
Too much slag in steel	17	4.4	In these cases casting has been stopped mainly because of slag, but often boiling of steel in the mould has been other reasons
Too low steel temp. by casting with 1 strand	11	2.8	Casting with 1 strand is depending on other problems. In these cases more than 5 tons steel back
Overflow	11	2.8	Caused by bad mould lubrication,mechanical machine problems and human errors
Problems with sliding gate nozzles	10	2.6	Share of problem higher than normally. One cause may be too high steel temperatures
Problems with shears	6	1.6	Share of problem with shears has gone doen (4.1% in April)
Electric disturbance	4	1.0	
Plate brick from tundish bottom came off	4	1.0	New problem caused by negligent working of one tundish repair man.Problem is no more topical

Name of disturbance	Number of disturbances	% of all strands	Remarks
Tundish nozzle too big because of oxygen burning in the beginning of casting	4	1.0	Mainly caused by starting with open nozzles. Problem is no more very serious because starting with open nozzles has decreased considerably
Too high steel temperature	4	1.0	Steel is sent back directly because of extremely high steel temperature or bolts of dummy bar heads are molten due to the high temp.
Bolt of dummy bar head came loose	3	0.8	These problems we had more but they are in breakout column. We can improve the situation by using cooling scrap in mould before starting
Erosion of tundish nozzle too big during casting	3	0.8	Too high casting speed often causes breakouts and therefore most of this problems are in the breakout column
It was not possible to open tundish nozzle	3	0.8	Main cause of problems is slag in nozzle. Nozzle material cannot tolerate much burning with oxygen
Inclined tundish nozzle	3	0.8	Inclined stream is much more serious problem, because it causes many other disturbances. In these cases casting has been impossible
Too high S-content cracks on the billet corners	2	0.5	Too high S-content has during May been a big problem
Too cold strand bent after straightening machine	1	0.5	

Name of disturbance	Number of disturbances	% of all strands	Remarks
Transverse moving of tundish car out of use	1	0.25	There are very often problems with this moving but now casting impossible
Total number of disturbances	123	31.9	Some improvements compared with April. In March the situation was better (27.4 %)
February	131	51	
March	118	27.4	
April	103	35.3	

We can see that the total situation has improved compared with Apri-, but (27.4%) the result of March was not reached. We cannot be satisfied before 10-15 % disturbance level is reached (target). It is pleasing that we have reached our target concerning breakout rate. Target placed before was to reduce breakout rate from previous level 10-15 % down to 5 %, which is not good, but acceptable. Normal value by billet casting in similar plants is 0.5 - 2 %. Annex 1 presents weekly breakout rate 1980 (last [illegible]k 1.2 %).

Importance of mould cooling for continuous casting

It is often said that the mould is the soul of the continuous casting machine and naturally souls must be handled with care. There are different models of moulds for example:

- blockmould (used earlier but now very seldom)
- seamless tube mould
- platemould

For Gecosteel only tube mould is interesting. A normal material for a tube mould is with phosphorus deoxidized electrolytic copper. The hardness of mould is normally 80-90 HB. Nowadays the inside of the tube mould is almost without exception chromium plated. Chromium layer is normally ca 0.08 mm thick and hardness after one measurement in Koverhar in Finland was HV 736 (copper itself HV 92).

It is possible to use some copper alloys, which are much harder than normal copper. For example copper alloy 0.5 - 0.8 % Cr it is possible to reach minimum hardness 130 HB and with Cu-Cr-Zr-alloy (0,7 % Cr and 0.06 Zr), it is possible to increase hardness up to 160 - 180 HB. It should be mentioned that we proved this kind of tubes in Imatra in Finland, but the results were not better than with tubes from normal copper.

The situation is however quite different by big blooms and slab moulds.

1. Tapering of mould

Nowadays almost all tube moulds are 0.4-0.9 % tapered, because it is possible to reduce and control gap formation between mould wall and strand. If only the upper part of the mould is tapered (half tapered mould) tampering can be much bigger (1-2 %). Gecosteel is using moulds which are tapered on the whole length. Tapering of most of the new moulds have been correct.

2. Heat transfer from the mould

It is useful to examine heat transfer and transferresistance between molten steel and cooling water. In picture 1 we can see different layers between molten steel - cooling water and in picture 2 a cross-section of a mould.

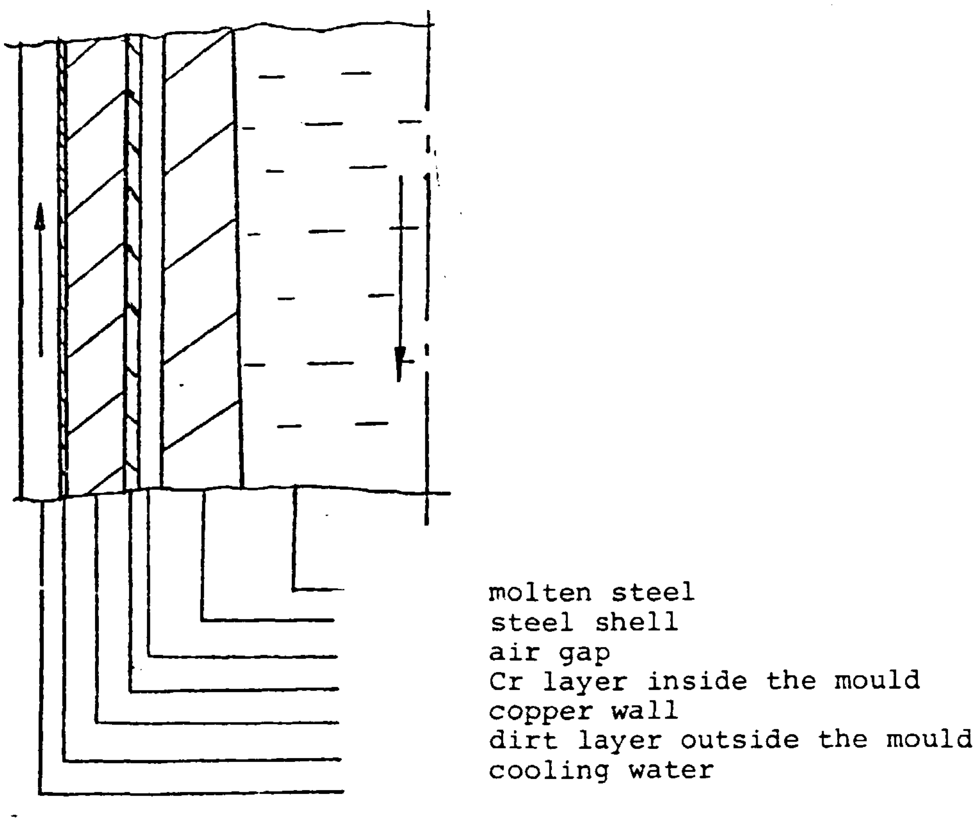


Fig. 1 Different layers between molten steel and cooling water.

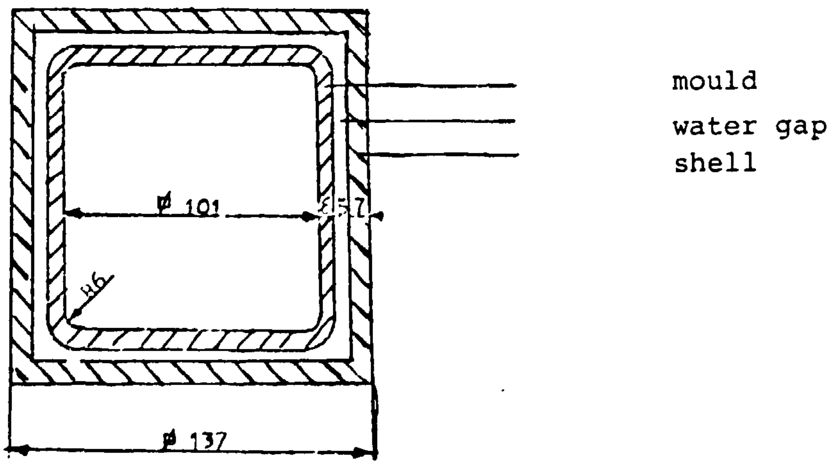


Fig. 2 Cross-section of a mould.

In the following table it is possible to see the shares of different heat resistance in mould cooling according to an example.

	%	Temperature gradient °C
Resistance of heat transfer through solidified steel shell	34.5	463
Resistance of heat transfer in air gap	56.3	769
Resistance of heat transfer through the mould wall	3.3	28
Resistance of heat transfer between cooling water and mould wall	5.9	64

We can see that the predominantly highest resistance of heat is caused by air gap.

Because of the above mentioned the control of air gap is the most important matter by planning mould cooling.

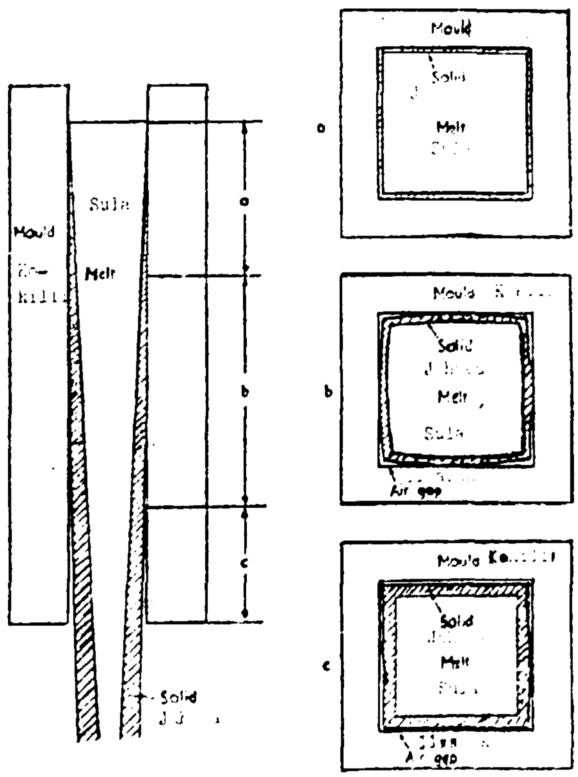


Fig. 3 The heat transfer zones of continuous casting moulds

a. direct contact between steel and mould wall.

b. formation of air gap

c. growth of shell

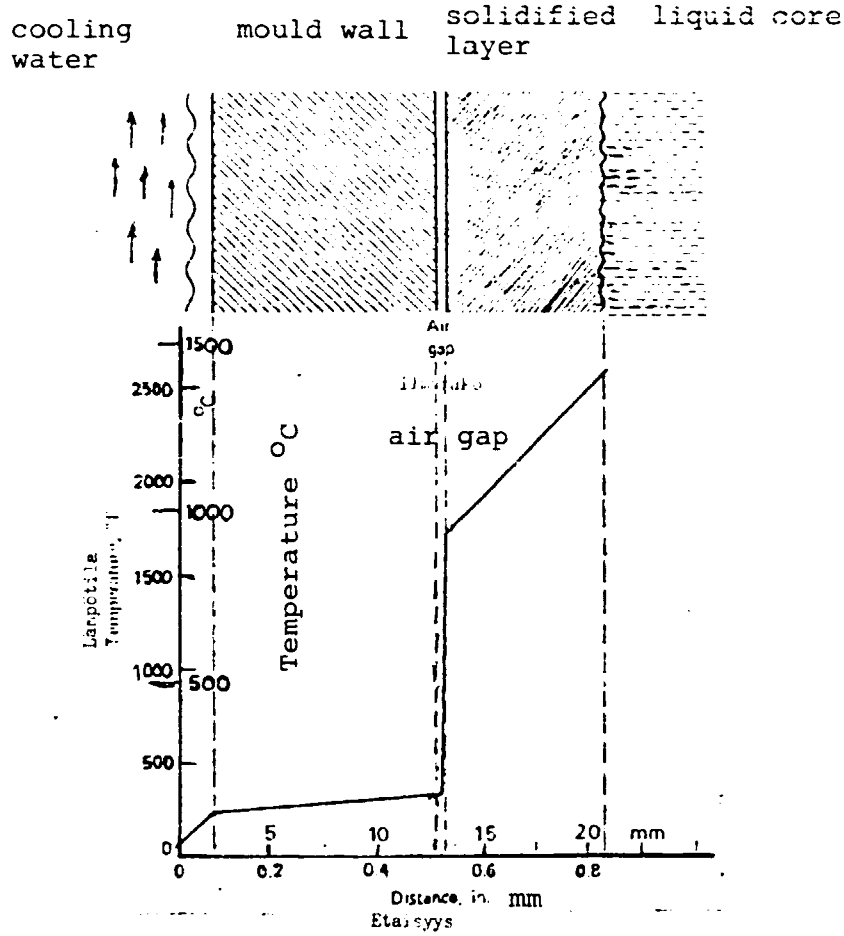
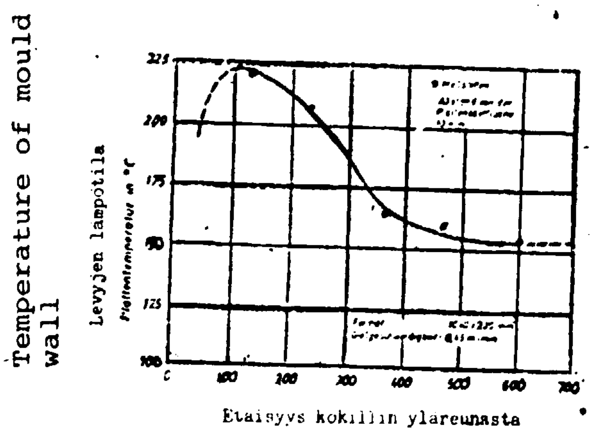


Fig. 4 The average distribution of temperature in mould cooling.

Fig. 5 presents the dependence of mould wall temperature on the distance from steel meniscus.



Distance from the top of the mould in mm

With tapering of the mould we can increase the heat transfer from the mould ca 15 %. By using higher casting speeds the effect of tapering is bigger. Fig. 6 and 7 present some investigation results.

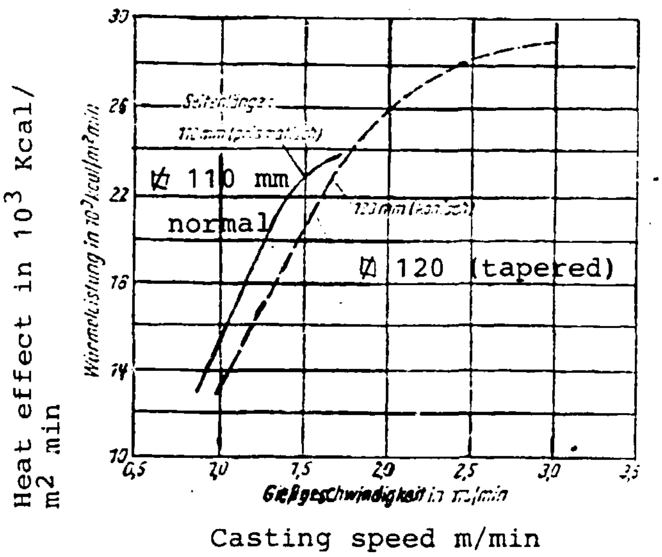


Fig. 6 Comparison of the heat transfer effect between tapered and normal mould with parallel walls.

The heat transfer from the mould is depending not only on tapering but also very much on deformations of the mould walls. Easiest we can get deformations of the mould in area of steel meniscus, where the wall temperature of the mould is highest. Every deformation decrease heat transfer from the mould locally, and aneven cooling is obtained as a result. Because of deformations friction between solified shell and mould wall will be bigger.

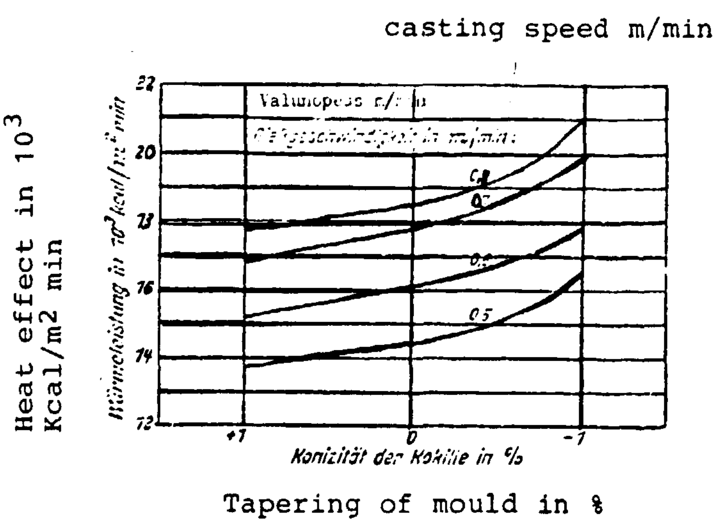


Fig. 7 The influence of tapering and casting speed on the heat transfer from the mould.

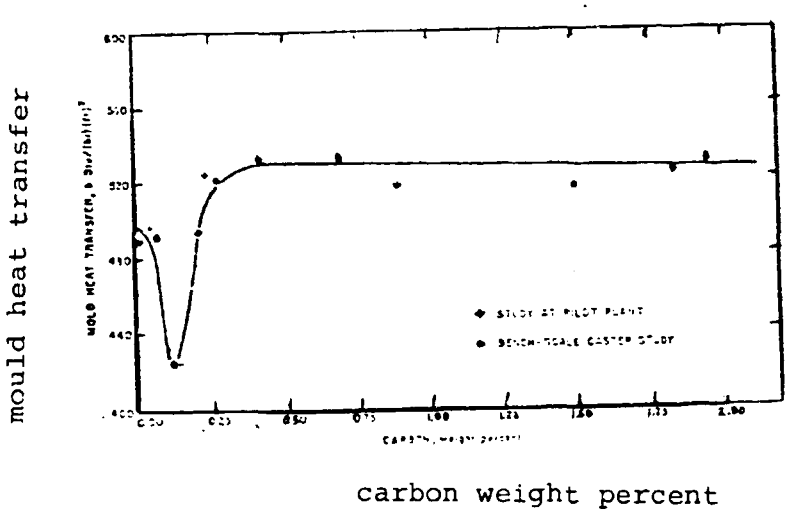


Fig. 8 The influence of carbon content on the total heat transfer coefficient.

In both cases we can see that the heat extraction from the mould is lowest with the carbon content ca 0,1 %, and Fig. 10 shows how much smaller the shell growth is in the mould by casting low carbon steel instead of high carbon steel.

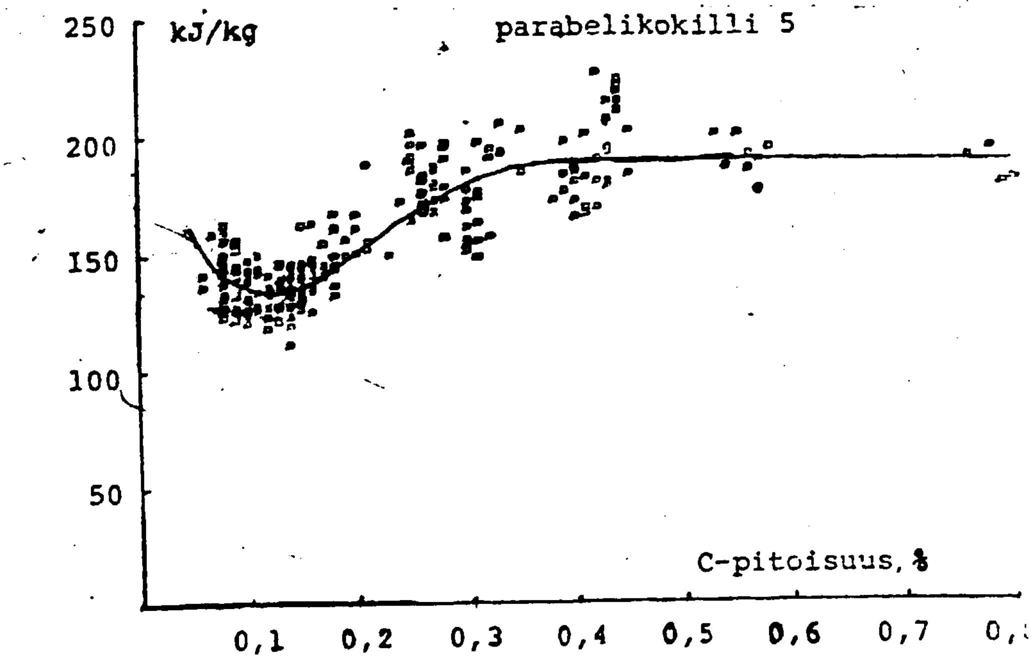


Fig. 9 The influence of carbon content on heat extraction kJ/kg from the mould.

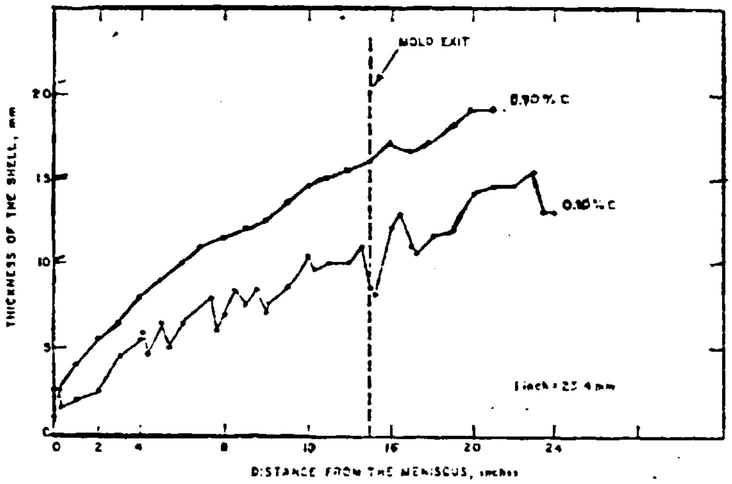


Fig. 10 Thickness of steel shell in mould by C = .10 and .70 %
carbon contents.

It is possible to see too, that the thickness of solidified shell is varying very much by casting low carbon steel.

Because of the above mentioned the number of breakouts are slightly higher by casting low carbon steel, but breakouts are no bigger problem if mould cooling and secondary cooling are efficient and even.

3. Mould cooling at Gecosteel

It has been many problems with mould cooling at Gecosteel. During the last 2-3 months some improvements have happened, but there is still much room for improvements.

3.1 Quality of cooling water

Earlier it was many problems because of too hard mould cooling water. At this time untreated cooling water has been used and the results were catastrophic due to the deposits (e g $CaCO_3$) on the mould wall. After starting the water softening plant again, the problem was solved. It is still possible to see some black deposits on the mould wall on the steel meniscus area. Probably there are some dirt in the closed mould cooling system (iron oxide). It is recommended to clean the moulds every time when they are coming to the workshop. Mostly this cleaning has been made, but not always.

3.2 Mould lubrication

Concerning the mould lubrication there is an other report , but some important points should be mentioned. Even and sufficient mould lubrication is naturally one important precondition for effective and stable production. At the moment lubrication is not good enough. The biggest problem is the distortion of oilplate in case of overflow. Oil is often coming out through the copper gasket. The solution is remachining of plates, making of new plates, providing an O-ring between oil plates and a new cast iron oilplate.

These changes are now slowly going on.

Again the importance of cleaning of the mould and oilgap after every casting should be reminded. This work has very often been neglected.

3.3 Mould shape

Gecosteel is using tapered chromium plated moulds from Gabelmetal Osnabrücken (W.Germany). Tapering is about 0.6-0.8 %. All moulds have been measured so that we can see the shape of new moulds. When the moulds are coming to the workshop from the continuous casting plant, it is good to measure possible deformations in the area of molten steel up to 400 mm down from meniscus. In this area max allowed deformation is ca 0.5 mm. Before the measurements and the control the mould must be properly cleaned. How the measurements have to be made, we have gone through with respective mould repairing people. In the lower part of the mould we can tolerate bigger deformations and wear of mould wall. We often have had discussions with the respective maintenance people concerning dangerous mould defects.

3.4 Control of mould during casting operation

It is very important to know very accurately the whole history of the mould during its using time. Almost every casting disturbance has influence on the mould condition and the mould life. Now we have made a special mould card to follow the mould in the casting plant and in the mould repairing workshop. On annex we can see one example of a filled mould card. The card has been taken in practical use for some weeks ago.

On the card we must write all actions taken by maintenance and operation people. It is very important to explain accurately every disturbance taken place under casting operation. On the card we have code numbers for the five most common disturbances. If code no 6 (other reasons) is used, it is necessary to write with 1-3 words the name of disturbance . When the mould must be scrapped, it is very important to tell exactly why.

1981-05-10

Mauri Peltonen

LIST OF TECHNICAL PAPERS WHICH MR MAURI PELTONEN HAS HANDED OVER TO GECOSTEEL.

Ser. No	DESIGNATION	NOTE
1.	Concast mould control - infrared system for measurement and control of the mould level.	Concast publication
2.	Graphite containing refractories	Refractory Journal 1980
3.	Continuously cast steels at Imatra Steelworks	Finland - Imatra
4.	The outlook for steel in America. George A Stinson	6th Concast Convention
5.	Operation & quality of new bloom caster at Chita Plant of Daido Steel. T Kishida & Y Haseyawa	6th Concast Convention
6.	Steel melting praxis; by Hylsa de Mexico for low carbon, high carbon and micro-wire steel.	Dec. 10. 1976
7.	Opening address H Weiss, chairman of the Board of Concast AG	6th Concast Convention
8.	The Qarnex cold tundish system D Vincent and J H Courtenay Fassero Steel Mills International Limited	International Ltd
9.	Some technical consumption information from Japanese billet & blooms caster	October 11, 1975
10.	Suitability of the continuous casting process for the manufacture of cold heading wire rods. M Peltonen, J Sasse, E Ström Imatra Steelworks, Finland	
11.	Improvements of continuous casting of steel in square-section moulds. V P Perminov, K E Girskii	
12.	Essentials and auxiliary operations for the continuous casting of the billets Luis M Saurez Alvarez (Ensidessa, Spain)	
13.	Computer control of arc furnaces Paper given at the ASEA Steel Symposium in London 1978-04-06	By Lars Karlsson
14.	Concast Metallurgical Seminar on billet/bloom casting of special steel Dr E Fürjes, Hungary, Zürich, October 1979 Recent operational Experience with the 6-strand billet caster at Ozd. Dr E Fürjes Hüttenwerk Ozd. Hungary	

Ser. no	DESIGNATION	NOTE
15.	Production of steel in electric arc furnace and productivity study	By Magnus Eidem ASEA AB, Sweden
16.	Condition for optimum arc furnace operation Kjell Bergman, Furnace Department, ASEA	ASEA, Sweden
17.	The production and application of continuously cast AISI 1008/1010 steel at Georgetown Steel Corp. W T Litto and O W Candy, USA	
18.	Continuous casting of blooms at Sumitomo Metal A Yashida and A Mori at the 6th Concast 1981 Convention	
19.	Summary of tests to improve the life of mould tubes P Koenig, Concast AG	
20.	Continuous Billet Casting of high grade steel at OVAKO, Finland Erkki Ristimaki, OVAKO - Research Centre, Imatra, Finland	
21.	Moulds key element in continuous casting H Marti and J Barbo	Concast Zürich
22.	Influence of carbon content on the rate of heat extraction in the mould of a continuous casting machine.	
23.	On the formation of an air gap between the mould and the strand in continuous casting H Fredriksson and M Thegeström The Royal University of Technology, Stockholm, Sweden	
24.	Continuous casting inspection progressive approach in tundish technology	Steel Times April 1980
25.	Continuous casting cooling water flow control E E Kurzinski, Pennsylvania Engineering Corp.	Iron & Steel Engineering October 1979
26.	Basic results during commisioning at Concast-ASEA electro magnetic slab stirres H Haefekerm Concast AG, Zürich	6th Concast Convention 1981
27.	Operational and quality results of combined billet/bloom/slab caster for stainless steel Y Kotani, Nippon Stainless Steel Company	6th Concast Convention 1981

Ser. No	DESIGNATION	NOTE
28.	On solidification control in continuous casting Dr Mannfred M Wolf	6th Concast Convention 1981
29.	Electro-Magnetic stirring on Lukens slab caster (J F Longenecker, T W Lewis, H E Woodrutt), Lukens and Co Williamson Concast	6th Concast Convention
30.	On the continuous casting of bar products in stainless and other highly alloyed steels C H Fuchs, Concast AG, Zürich	
31.	Problems in the casting of stainless and high alloy steels V P Ardito and R A Walsh Allegheny Lodlum Steel Corporation	6th Concast Convention 1981
32.	Features and developments in continuous casting of billets and blooms F Neumann, Concast AG	
33.	Start-up of the USINOR - Thionville (4-strand billet caster) R Blain	6th Concast Convention 1981
34.	New results on productivity and products quality after modifications of the two billet casters H Nunotani, Nakoyama Steelworks, Japan	6th Concast Convention 1981
35.	Energy saving in continuous casting operation S Iwamora, M Iguchi, M Sumo, Toshin Steel Co Ltd, Tokyo, Japan	6th Concast Convention 1981
36.	Bloom casting of fine-grained steels, SSAB-Luleå, K F Jonsson Svenskt Stål AB - Luleå, Sweden	6th Concast Convention 1981
37.	High carbon steel production at Georgetown Steel Corp. B S Romsdale, Georgetown Steel Corp., USA	6th Concast Convention 1981
38.	Operational and quality of new bloom caster at Chita Plant of Daido Steel T Kishida, Y Haseyawa, Daido Steel Co Ltd, Chito	6th Concast Convention 1981
39.	Africas largest billet casting plant under construction at the Delta Steel Company, Aladja, Nigeria Dr S Adelukum, Dr J Ewery	
40.	Minimising the cost of maintenance	Steel Times December 1980 Pages 844-849
41.	Control of parameters in continuous casting practice influencing the surface finish and internal cleanness of the steel	Iron & Steelmaking 1977, No 6

Ser. no	DESIGNATION	NOTE
42.	Segregation in continuously cast steel Imatra Steelworks, M Peltonen	
43.	The result of melting direct reduced iron by UHP arc furnace by Toshio, Sanji Daido Steel, Shito Works, Japan	Steel Times February 1980 p 137-143
44.	Direct reduction - what does it mean to the steelmakers. J W Brown	Iron and Steel Engineer June 1970, p.37-46
45.	Use of direct reduced iron ore and balanced integrated iron and steel operation J R Miller	Iron & Steel-making 1977 No 5 p. 257-262
46.	Electric arc furnace steelmaking with sponge iron J W Brown and R L Reddy	Iron & Steelmaking 1977 No 1
47.	The development of a new steelmaking process utilizing highly metallized sponge iron H M Williars and R C Madden	Iron and Steel International August 1975 P 313-321
48.	Utilization of DRI in iron and steelmaking Alfandi Dach'an Maman Abdul Rachman	Steel Times February 1980 p 131-136
49.	Direct reduction and its application (some operating results and implementation	p 125 - 127
50.	Continuous billet casting "an introductory key note" by W Heinmann, Concast AG, Zürich	Concast Metallurgical Seminar 1978
51.	"Continuous casting starting procedure at Tremorfa Steelworks " by P M Rich G K N, Tremorfa Works	
52.	Experience of two years casting with multi-stage (MS)-moulds Rubensdörffer of Röchling	Concast Metallurgical Seminar 1978
53.	Operation and performance of the two billet casters at Nakayamas Funamachiworks By K Kinoshita and H Okawa	Concast Metallurgical Seminar 1978
54.	Development of continuously cast steels for special quality application for bar and rod Sheerness Steel Company Ltd By T Jarvis and B S Ramsdale	Concast Metallurgical Seminar 1978

Ser. No	DESIGNATION	NOTE
55.	An approach to process and cast high quality steel in a plant originally schedulling for Rebar production By D Reiber of Von Roll/Switzerland	Concast Metallurgical Seminar 1978
56.	Continuous billet casting of high grade steels at OVAKO by E Ristimaki	Concast Metallurgical Seminar 1978
57.	Application of dolomite ladles in an electric steel plant with two continuous casting installation for high rate billet casting By D Ameling and K Walden of Hamburger Stahlwerke	Concast Metallurgical Seminar 1978
58.	Cold tundish practice at Iscor's new cast works By R K Newton	Concast Metallurgical Seminar 1978
59.	Refractories for continuous casting K K Koppmeyer, G K Russel, D H Hubble	Iron and Steel International October 1974
60.	A practical solution to the problem of aluminium build up in nozzles during continuous casting of aluminium-containing steels By S N Singh.	
61.	Lining protection for continuous casting tundishes C W Hardy (B.S.C. Research Organization)	
62.	Effect of deoxidation practice on billet quality K Walden, G Rudolph, Dr D Anelin	Concast Metallurgical Seminar 1979
63.	Tundish liners: A key to quality and productivity M D Whiloch Presented at Concast Specially Steel casting Conference 1979	Conference 1979
64.	Taking refractories to the limit in steel By George J Mc Manus	Iron Age August 6, 1979
65.	Concast billet bloom continuous casting seminar in Sapporo, 1980	
66.	Comparison of the influence at straight and curved mould continuous casting machines on product quality.	
67.	Entrapped slag in continuous cast steel billets H Mori, Yowota Iron, Japan	

Ser. No	DESIGNATION	NOTE
68.	Questions, which should be dealt with by visiting different continuous casting plants. Mauri Peltonen	
69.	Schlacken und oxydishen Einschlüsse beim Strang-giessen von Stahl. Emil Elsner, Hubert Knapp, Korf Stahl Baden-Baden Dieter Ameling, Gunter Rudolf, Hamburger Stahl-werke	
70.	Comments about discussions in Hylsa do Mexico S A December 1976 Different problems of billet casting has been dealt with Mauri Peltonen	
71.	Improving safety and productivity in tundish pre-paration Foseco Steelmills International Steel	Times, April 1978
72.	Qualitätstand beim Stranggiessen von Vorblöcken und Knüppels Rudolf Jouch, Völklingen	Stahl und Eisen 98 (1978) Nr 23 März
73.	Strand casting steel for hot forging and cold heading application Roblin Steel Company, USA	
74.	Development and effect of calcium adding techno-logy into molten steel. Tachuro Vemura, Sumitomo Works	
75.	Einsatz von feuerfesten Werkstoffen in der Eisen-hüttenindustrie	Stahl und Eisen 99 (1979) Nr 21, 22 Okt.
76.	Improving quality of continuously cast strand by stirring steel in mould. Ju A Somojlovich Stahl 1980 (3) 191-193	Steel in the USSR
77.	Quality aspects at continuous casting steel By A L Collings A.S.M.B. The Broken Hill Proprietary Company 206 Metals Australia August 1970	
78.	Ladle injection as a mean for improving the quality of steel By Seppo Härkönen, Oy OVAKO Ab, Finland	
79.	High-rate continuous casting of steel billets By Wolfgang Weinreich	Steel Times October 1970